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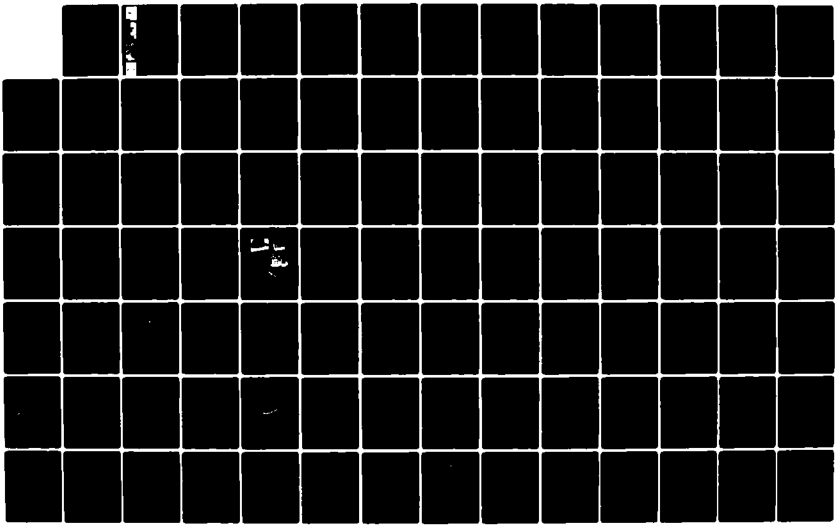

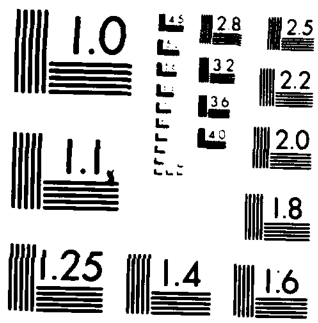

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US Army Corps of Engineers

TECHNICAL REPORT GL-83-5

SURFACE AND SUBSURFACE GEOLOGIC CONDITIONS ALONG SELECTED REACHES OF THE MISSISSIPPI RIVER FROM ROSEDALE, MISS. TO LAKE PROVIDENCE, LA.

by

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US ARMY ENGINEER WATERWAYS EXPERIMENT STATION

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Continuous acoustic subbottom profiling was conducted in 100 miles of the Mississippi River channel near Lake Providence, La., and from below Greenville, Miss., upstream to Rosedale, Miss. Subbottom profiling and other geologic, hydrographic, and topographic data were analyzed to determine the depth, composition, and extent of important geologic horizons beneath the channel and surficial deposits adjacent to the channel in the floodplain. The Tertiary surface as well as bedding and structure within the Tertiary were interpreted
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from the subbottom profiles for most of the survey area. The geology and stream geometry (thalweg slope and sinuosity) were compared for the river segments studied to determine their relationship to stream degradation and aggradation. Geologic profiles and maps were constructed at an original scale of 1:20,000 from all available data for the surveyed areas and are presented in the report. Computed thalweg slopes for the survey segments were generally flat or increased in elevation in a downstream direction, implying a tendency for the channel to shoal, especially in the Lake Providence and Greenville reaches. Regional geologic structure, the lithology of Tertiary deposits underlying the Mississippi River, and alluvial deposits of variable erosion resistance in the floodplain apparently hamper the river's ability to deepen its channel and to maintain sufficient flow velocity to prevent aggradation in the study reaches.

PREFACE

This study was authorized by Intra-Army Order for Reimbursable Services No. 3492, dated 12 February 1979, from the District Engineer, U. S. Army Engineer District, Vicksburg (VED), CE (LMKED) to the U. S. Army Engineer Waterways Experiment Station (WES).

This study was conducted during the period February 1979 to January 1980 by Messrs. W. L. Murphy and J. R. May of the Engineering Geology and Rock Mechanics Division (EGRMD), Geotechnical Laboratory (GL), WES. The report was prepared by Mr. Murphy. The report was presented in draft form to the Vicksburg District in 1980 for the immediate use by VED Potamology Section personnel, who subsequently recommended the report be published for wider distribution. The report was then prepared for publication in 1982-83. Direct supervision of this study was provided by Mr. J. H. Shamburger, Chief, Engineering Geology Applications Group, EGRMD. General supervision was provided by Dr. Don C. Banks, Chief, EGRMD, Mr. James P. Sale, former Chief (Retired), GL, and Dr. W. F. Marcuson III, Chief, GL.

Acknowledgment is made to Messrs. B. R. Winkley, R. E. Rentschler, and D. R. Williams of the LMKED Potamology Section and Mr. J. Tuttle of the Lower Mississippi Valley Division, CE, for their helpful suggestions during the study and for review of the report.

Directors of WES during the conduct of this study were COL John L. Cannon, CE, COL Nelson P. Conover, CE, and COL Tilford C. Creel, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
feet	0.3048	meters
feet per mile	18.93935	centimeters per kilometer
feet per second	0.3048	meters per second
miles (U. S. statute)	1.609347	kilometers

SURFACE AND SUBSURFACE GEOLOGIC CONDITIONS ALONG SELECTED REACHES OF THE MISSISSIPPI RIVER BETWEEN ROSEDALE, MISS., AND LAKE PROVIDENCE, LA.

PART I: INTRODUCTION

Background

1. The Potamology Program of the Lower Mississippi Valley Division (LMVD) is being conducted to obtain a better understanding of the mechanics and relationships, including geologic conditions, that influence changes in the channel geometry and meander patterns of alluvial rivers, specifically the Mississippi. Geologic conditions that can significantly influence channel characteristics include the presence of erosion-resistant materials (fine-grained alluvial deposits and bedrock units), structure (folding and faulting), and regional topography. An increase in flood profiles has been experienced since the 1930's in the Mississippi River between Arkansas City, Arkansas, and Old River, Louisiana. The largest increase within the problem area occurs in the Lake Providence Reach. The hydrographic survey of the Mississippi River (1973-75) indicates that the top bank elevation, relative to the low water reference plane (LWRP),* for the river is higher in the vicinity of Greenville, Mississippi, than in the Lake Providence Reach. Also, the Tertiary geologic formations near Greenville are different from the geologic formations near Lake Providence. A study was authorized to identify the surface and subsurface geologic conditions in two river segments to apply these data to the potamology program.

Purpose and Scope

2. The major concern to the LMVD is the cause of a significant increase in the flood profile of the Mississippi River between Arkansas City, Arkansas, and Old River, Louisiana, and the identification of conditions conducive to future changes and locations where changes can occur within that

* The Low Water Reference Plane is the average river stage from 1964 to 1974 that represents the discharge equalled or exceeded 97 percent of the time.

portion of the river. The purpose of this study was to determine the position, extent, and nature of geologic conditions underlying and adjacent to the Mississippi River channel in three selected areas and to compare the reaches on the basis of topography and geology. The study was also to determine the effectiveness of the subbottom acoustic profiling technique in riverine geologic engineering investigations.

Approach

3. The approach was to perform office and field studies for two segments of the Mississippi River: the Lake Providence Reach (468 to 504 Miles* Above Head of Passes or MAHP), and the Greenville to Rosedale segment (527 to 590 MAHP) (see Figure 1 for location). For purposes of discussion the latter segment is divided into the Greenville Bridge area and the Greenville to Rosedale segment. The office study examined available data such as geologic reports, boring logs, and topographic, hydrographic, and geologic maps. The field investigations applied the acoustic subbottom profiler, a reflection seismic geophysical tool, to the problem of determining the depth and attitude of important geologic horizons beneath the channel bottom. A continuous subbottom profile was made generally on or near the thalweg, for 100 miles of river covered by the survey. Cross-sectional profiles were made at selected locations by crossing the channel diagonally upstream. Subbottom acoustic data were obtained to depths of up to 120 ft below channel bottom. The acoustic data were supplemented by lithologic and geophysical logs of Corps of Engineers (CE) borings and water well borings.

4. The office and field data collected were analyzed to locate and map important alluvial and Tertiary features within the channel and in the floodplain between the levees. The 1973-75 Hydrographic Survey maps of the Mississippi River, November 1977, scale 1:20,000 (U. S. Army Engineer District, Vicksburg, 1977) were used as base maps to show clay plug and backswamp deposits along the banks and positions of submerged Tertiary outcrops in the channel thalweg and in scour holes. Boring locations, acoustic survey positions, and profile locations are also identified. The profiles were

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

constructed along the survey line, also at a scale of 1:20,000. The maps and profiles are presented as Figures 7-58 of this report. Each hydrograph map follows its accompanying profile in order in Figures 7-58. The original subbottom profile records can be viewed in the Geotechnical Laboratory, Engineering Geology Applications Group, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

PART II: SEISMIC PROFILING TECHNIQUE

Principle of Operation

5. The continuous seismic (or acoustic) profiling system is an application of the reflection seismic technique. The technique was originally developed for geophysical terrestrial exploration for oil and gas and later adapted to offshore marine deep exploration using towed acoustic sources and hydrophones. Refinements were made to the original sound source that permitted greater resolution of the reflections of subbottom geological features in the upper 200 ft. These refinements resulted in the continuous seismic profiling technique that is being applied to engineering geologic investigations (see USAE Waterways Experiment Station, 1980).

6. Compressional waves from a waterborne sound source are directed toward the bottom of the aquatic body and continue into the subsurface. If the waves encounter material of a different density/or and seismic velocity, part of the wave energy is reflected and returns to the surface where the reflection is recorded. Figure 2 illustrates the operation of the seismic profiling system. The higher the impedance (density times velocity) contrast between two media, the stronger the reflected signal will be. The profiling system converts incoming acoustic signals to usable electric signals which are printed on a paper record indicating depth to and slope of various horizons. The depths to the various horizons are based on the velocity of sound in water (approximately 4800 ft/sec). Saturated sediments exhibit similar or slightly higher velocities. Acoustic frequencies used in bottom penetrating sound sources are lower than those of bottom sounding Fathometers, i.e., on the order of a few hundred to several thousand Hertz (Hz).

Application and Limitations of Technique

7. The continuous seismic profiling technique as used in this study can be conducted in any navigable stream or water body capable of supporting at least a 35-ft-long shallow draft vessel. River stage affects the quality of the records. High water, especially water on the rise, carries much floating and submerged debris and suspended solids that interfere with towed equipment and produce a "dirty" record by scattering signals. Windy weather, especially

if the wind direction is upstream, churns the stream surface and produces false oscillations in the shape of acoustic and seismic reflections in the survey record. Fog and driving rain make positioning difficult and operating conditions hazardous. Bottom sediments containing entrapped air or a significant amount of organics (e.g., decaying leaves and wood) attenuate seismic energy and are thus difficult to penetrate. These problems are enumerated here only to identify ideal conditions for conducting continuous seismic profiling. Ideal conditions are desired but are not required to conduct successful surveys. If the schedule permits, the best weather and river conditions should be sought to eliminate as many of the above problems as possible so that the best seismic profile records may be obtained.

Seismic Profiling Equipment

8. Seismic profiling equipment for this survey was the EG&G Uniboom Model 230 system consisting of a single electromechanical transducer (sound source) mounted on a catamaran towed behind the survey vessel; an 8-element hydrophone streamer array that trails the vessel alongside the transducer; and a Model 234 energy source (power supply) and capacitor bank for generating the high-energy electrical pulse that produces the acoustic pressure pulse in the transducer (Figure 3). The energy source delivers up to 300 joules (watt-seconds) of energy. A 6.5-kilowatt (kw) 220-volt generator powers the energy source. The return signals are sent through a filter and amplifier and processed and displayed as a continuous record on an EPC Model 3200 graphic recorder and stored simultaneously on an analog tape recorder (Figure 3). The Uniboom is a high-resolution system operating at a frequency range of approximately 400 Hz to 14 kilohertz (kHz). The Uniboom is capable of penetrating to a depth of about 200 ft in sediments and can achieve a resolution of one to several feet.

9. An ORE Model 1032 12-kHz transducer was used briefly in the Greenville reach simultaneously with the Uniboom. The 12-kHz transducer is capable of higher resolution than the Uniboom but has less penetration capability. It was hoped that the 12-kHz unit would display shallow reflectors with greater clarity than that possible with the Uniboom, but the unit was unable to penetrate the bottom sediments and was not used further.

Data Obtainable from Seismic Profiling

Physical properties

10. Physical characteristics of the reflecting medium, such as lithology, strength, grain size, and velocity, cannot be directly identified from the seismic reflection record but are interpreted as follows:

- a. Lithology and grain size of a geologic unit represented by a reflector can be extrapolated by correlating with appropriate intervals in nearby boring logs.
- b. Relatively greater strength or hardness of a reflecting horizon with respect to other reflectors causes a reduced acoustic penetration and is indicated by a greater number of bottom multiple images appearing beneath the reflector. Multiple images in the record result when more of the seismic energy is reflected from a horizon than is passed through it, producing a number of reverberations. The reason more multiple images are produced is that a surface of relatively high strength usually exhibits a combination of high compressional wave velocity and density, and thus has a high reflectivity. High reflectivity can occur at the water-channel bottom interface if the bottom is relatively hard.
- c. "Soft," air-entrained sediments are usually identified on the acoustic record by a lack of penetration and an absence of multiples. The entrapped air attenuates the signal strength sufficiently to prevent penetration of the sediments.

Point-source reflectors

11. The presence of boulders, concretions and similar "hard-point" anomalies in a subbottom horizon is often indicated on the record by a series of hyperbolic surfaces that, taken together, impart a hummocky appearance to the reflecting horizon. Similar individual hyperbolic signals are produced over point-source reflections such as cylindrical or spheroidal objects. A buried pipeline crossing the path of a seismic line is an example of a point-source reflection. Similarly, bottom dunes or sand waves, which are common features of large streams, may produce side echoes that also yield hyperbolic signals on the record.

Geologic structure

12. Geologic structure is readily identified on continuous seismic profile records in the form of horizontal and parallel, dipping, contorted, or folded bedding horizons. However, the vertical exaggeration of a record is normally very high (approximately 56 vertical to 1 horizontal in the interpreted profiles in this report), and the slopes represented on the profiles

are much steeper than the actual slopes. Faults are indicated by unconformable lineations in the sediments and by offset of adjacent identifiable bedding horizons, but are difficult to distinguish if multiples, side echoes, and other spurious signals are present in the record. Possible faulting was detected in the Tertiary near MAHP 502 (see Figure 56). The contorted Tertiary bedding in Figures 27 and 31 may also exhibit some minor faulting.

Buried horizons

13. The horizon representing the top of the Tertiary strata (base of the river alluvium) is generally easy to distinguish on the profile if penetration through the alluvium is achieved. Other horizons within the alluvium, however, also often act as good reflectors and may resemble reflections interpreted to be Tertiary strata. Boring control should be available to verify the true Tertiary reflector in such cases. Examples of reflectors within the alluvium are as follows:

a. The tops of buried gravel-bearing or coarse-grained strata underlying finer sediments (usually recognized by their channel shape and limited extent).

b. Buried man-made structures such as revetment.

c. Former channel bottoms within the present channel that have been covered with very recent local deposits of bed load such as shoaling near the mouth of a tributary or siltation associated with artificial dike emplacement.

PART III: REGIONAL GEOLOGIC SETTING

Structural Features

14. Tertiary formations, the older, more indurated, slightly more consolidated deposits, form the floor of the entrenched valley of the Mississippi River. The term "valley floor" describes the base of the Mississippi River alluvial fill, and the top of the Tertiary sediments in which the valley was cut. Tertiary deposits are overlain by Pleistocene and Recent alluvial sediments that have filled the entrenched valley. The geologic structure and stratigraphy of the Tertiary units are important because the Mississippi River presently is eroding into the Tertiary in several locations and the past and present courses of the river may be influenced by structural trends and stratigraphic changes from location to location within the valley.

15. The study areas lie within the central portion of the Mississippi structural trough, a generally north-south trending syncline that plunges to the south. The present Mississippi River meander belt follows the axis of the structural trough for most of its length below Cairo, Illinois, to the Gulf of Mexico (Fisk, 1944). The northern portion of the structural trough (above the latitude of Greenville, Mississippi, approximately) forms the Mississippi embayment. The axis of the trough is displaced to the east by another structural feature, the Monroe uplift (Fisk, 1944; Wilbert, 1953). Figure 4 identifies the Tertiary units beneath the valley fill in the central part of the valley and shows the major structural anomalies. Figure 5 is the stratigraphic column of geologic deposits that form the valley floor. The Monroe uplift, which trends southwest-northeast, and Mississippi structural trough interact to form a depression, the Desha Basin, north of Greenville. The Desha Basin trends northwest-southeast (Figure 4) and its axis passes through the Caulk Cutoff area (approximately 575 MAHP).

16. The Mississippi structural trough is as old as Jurassic (Cushing et al., 1964), and the Monroe uplift probably as old as Cretaceous (Wilbert, 1953; Fisk, 1944; Cushing et al., 1964). Tertiary sediments within the study area are the younger Eocene sequences laid down within the structural basins, which were centers for deposition during the advances and retreats of Tertiary seas. The Monroe uplift was active through Tertiary time (Wilbert, 1953) and has elevated the stratigraphic section to expose the Claiborne group of beds

(Cockfield formation) in the entrenched valley between Greenville, Mississippi, and Cottonwood Bar (below Lake Providence, Louisiana). The Desha Basin existed as a structural depression, partially isolated from the rest of the Coastal Plain by the Monroe uplift, when the late Eocene seas advanced to deposit the marine Jackson group of sediments (Yazoo clay and Moody's Branch marl). Therefore, Jackson sediments deposited within the Desha Basin may differ somewhat from Jackson sediments found elsewhere in the embayment because of the partially isolated position of the Basin (Wilbert, 1953).

17. The Mississippi structural trough has probably determined, or at least greatly influenced, the initial course of the lower Mississippi River and its tributaries. Gradual filling-in of the valley by Recent alluvium has allowed the present meandering river to seek a course largely independent of the trough axis. The trough itself is now thought to be a direct consequence of tectonic rifting of continental plates or subplates. Specifically, the trough may be a failed arm of a triple-junction plate boundary, of which the northern boundary of the Gulf of Mexico forms the other two arms as the spreading center between the plates (Wood and Walper, 1974).

Tertiary Stratigraphy

18. The Mississippi structural trough contains formations as old as Jurassic through Tertiary, with units decreasing in age generally toward the center and to the south within the trough. This study is concerned with formations of the Tertiary Eocene Claiborne and Jackson Groups. The Cockfield and Yazoo formations form the valley floor of the Mississippi River in most of the study area (Figure 4), i.e., if the valley alluvium were stripped away, the Cockfield and Yazoo formations would exist as outcrops within the study area.

The Claiborne group

19. The occurrence of deposits of Claiborne group age (primarily Cockfield) within the study area is mapped in Figure 4. The Cockfield formation (formerly "Yegua," Grim, 1936) is the youngest and probably the only Claiborne unit encountered on the valley floor in the study area. The Cockfield is nonmarine and consists primarily of thick, massive sands in its lower portion and progressively finer deposits toward the top. Lignite, carbonaceous silty shales or clays, and lenses of lignitic to nonlignitic sands predominate in

the upper Cockfield (Thomas, 1942). The Cockfield is an important aquifer in parts of Arkansas, Mississippi, and Louisiana, and has been extensively studied from water well logs and surface outcrops. The Cockfield attains a maximum thickness of 500 to 600 ft in west central Mississippi, northeast Louisiana, and southeast Arkansas (Thomas, 1942; Fisk, 1944; Cushing et al., 1964; Taylor and Thomson, 1971). The conspicuous exposure of the Claiborne (primarily Cockfield) in the Lake Providence area around the axis of the Monroe uplift, while it remains buried beneath the younger Jackson sediments elsewhere, is evidence of the influence exerted by the Monroe uplift. The Cockfield is considered less resistant to erosion than the overlying Jackson deposits because of its generally sandy nature. However, the occurrence of fine-grained materials (clays, shale, and lignite) in the upper portion of the Cockfield should render it locally more resistant.

The Jackson group

20. The marine Jackson group is represented in the study area by the thin basal Moody's Branch marl and the overlying thick Yazoo clay. The Jackson group is exposed beneath the valley alluvium south of Lake Providence in a northeastward-trending belt from near Harrisonburg, Louisiana, to Yazoo City, Mississippi, and is widespread in the depositional basins north of the axis of the Monroe uplift (Figure 4). The Jackson is as thick as 500 ft where the entire section is present (Cushing et al., 1964) but is probably no more than 125 to 190 ft thick in the study area (Fisk, 1944; Taylor and Thomson, 1971). The Moody's Branch, 20-30 ft thick where present, is a fossiliferous marine glauconitic sand, becoming marly toward the top and is easily distinguished in outcrops from the nonfossiliferous Cockfield below and the Yazoo clay above. The Moody's Branch-Cockfield contact is transitional in a 1- to 10-ft-thick interval at the base, with inclusions and pockets of both formations present in the contact zone (Thomas, 1942). The Yazoo consists primarily of a thick sequence of massively bedded, calcareous, fossiliferous clays with occasional silty, lignitic zones. Several thin limestones occur in the upper 50 ft of the formation (Priddy, 1960). The Yazoo is commonly recognized in geotechnical borings as a highly plastic clay, CH (Unified Soil Classification System), and is considered by the author to be resistant to erosion (scour) by its effect on channel configuration above Greenville and because it is a cohesive soil. The relatively thin Moody's Branch has seldom been identified in geotechnical borings.

Alluvial Geology

21. The alluvial geology of the Mississippi River valley was described in Fisk (1944). The main features and characteristics of the valley are reiterated here so that the local conditions encountered in this study can be related to the regional setting. According to Fisk, the entrenched valley was carved in Pleistocene time and was filled after the close of the Pleistocene with Recent alluvial sediments. Coarse materials were deposited first when steep gradients dominated, and progressively finer deposits were laid down as sea level rose. The valley fill consists of a substratum of pervious gravelly and nongravelly sands and a top stratum of relatively impervious silty sands, silts, and clays. The distribution and thickness of the substratum varies greatly within the valley, being thick where it overlies deep entrenched meanders of the Pleistocene valley and thin or absent where the present Mississippi River has cut through it and is scouring pre-Quaternary sediments. The upward transition from coarse to fine strata is gradual, and distinct breaks from gravelly to nongravelly sands are probably the exception rather than the rule. Recognition of the substratum contact, however, was made locally in subbottom profiling for this study.

22. The top stratum consists of riverine and overbank sediments eroded and deposited during the seasonal stages of the river. The top stratum deposits are classified by Fisk (1944) as follows:

- a. Natural levee, the broad low ridge paralleling the channel that was laid down by overbank flooding and is made up of silts, sandy silts, and silty clays.
- b. Point bar deposits are interbedded silty sands and silty clays forming the upper 15 ft or so of sandbars. High water silty sands alternate with thinner deposits of silty clays deposited at low or slack-water stages.
- c. Backswamp deposits are silty clays and plastic clays that fill low-lying areas within the floodplain during overbank flows. Backswamp deposits have a high organic content of decaying logs, stumps, leaves, and other vegetable matter. They increase in thickness southward, from about 30 ft near Memphis to about 40 ft at Vicksburg.
- d. Abandoned channels are clay plugs or point bar slough fillings consisting of clay, silty clays, silts, and variable amounts of silty sand and sandy clays. Clay plugs vary greatly in thickness from several feet to over 100 ft.

23. The range of grain sizes to be expected in the four environments of deposition discussed above is shown in Figure 6. The data of Figure 6 are taken from grain size distribution graphs of Plate 70 of Fisk (1947). Samples for the grain size data represent the entire alluvial valley from Cairo, Illinois, to the vicinity of Baton Rouge, Louisiana. Fine-grained deposits, particularly clay plugs, are generally considered to be more erosion-resistant than coarser deposits, such as natural levee and point bars. The overlap and superposition of grain size curves of Figure 6 implies, however, that little actual difference in grain size exists between the four depositional environments. Possibly other characteristics of these deposits, such as cohesion, thickness, shape, angle of attack by the stream, and so on, should be investigated regarding resistance to scour and less emphasis placed on grain size. Such investigation is beyond the scope of this report.

Valley Slope

24. The LWRP (see footnote, p 4) for the 1973-75 Hydrograph, Mouth of White River, Arkansas, to Black Hawk, Louisiana, serves as an indicator of valley slope (U. S. Army Engineer District, Vicksburg, 1977). The valley as represented by the LWRP in the segment of river covered by the 1973-75 hydrograph, 610 MAHP to 310 MAHP, is concave upward, that is, steep in the upper reaches with decreasing gradient downstream. From 610 MAHP, 20 miles above Rosedale, Mississippi, to 488 MAHP at Lake Providence, the slope of the LWRP is 0.43 ft/mile; from 488 MAHP to 432 MAHP, just below Vicksburg, it is 0.38 ft/mile; from 432 MAHP to 350 MAHP, about 14 miles below Natchez, it is 0.33 ft/mile; and from 350 MAHP to 310 MAHP, at Old River, it drops to 0.13 ft/mile. The decrease in slope downstream is not uniform, because the river locally flattens or steepens its gradient for a few miles.

25. The mean thalweg slope is another indicator of the river's response to local grade, discharge, and load requirements. The average thalweg slope was computed for the segments of the river (Figures 7-58) that were surveyed and mapped for this study. The thalweg as shown on the profiles (see Figure 7) is the curve defined by points of lowest channel elevation on 1973-75 hydrograph soundings. The "mean thalweg line" of the profiles is a best-fit linear regression line calculated for the thalweg curve. By definition, a stream is considered "normal" when its average bed (thalweg) elevation decreases

downstream. Logically, the "normal" thalweg slope should be positive in a downstream direction. A negative thalweg slope for a segment of the stream would, therefore, be "abnormal" and would imply that the stream segment is out of grade with respect to the stream as a whole. Mean thalweg slopes measured for the segments of the Mississippi investigated in this study (see Figure 1) are predominantly flat to negative. Presumably those areas of negative slope are out of grade and still adjusting. The Lake Providence Reach shows the most extensive and steepest negative thalweg slope of the study area, with slopes locally as high as -8.6 ft/mile.

PART IV: DATA ANALYSIS

Seismic Profiling

26. The Greenville-Arkansas City Reach was profiled first from 528 MAHP to 566 MAHP, then the Lake Providence Reach from 468 MAHP to 504 MAHP, and, finally, Arkansas City-Rosedale Reach from 565 MAHP to 590 MAHP (Figure 1). Selection of the reaches to be surveyed was coordinated with the needs and priorities of Vicksburg District Potamology personnel. The sites were surveyed at river stages high enough to produce records of good quality (deep water yields records relatively free of interference from bottom multiple images) and low enough to allow alignment of the boat with known points on the bank for positioning. The Greenville-Arkansas City reach was profiled at a stage of about 38 ft (Greenville gage, bankfull is 48 ft), the Lake Providence Reach at about 20 ft (Vicksburg gage, bankfull is 44 ft) and the Arkansas City-Rosedale Reach at about 17 ft (Rosedale gage, bankfull is 44 ft). Profiling was done in the summer of 1979.

27. The profiles were constructed to show the general valley slope represented by the LWRP, the 1973-75 thalweg profile, the interpreted top of the Tertiary, and other detectable horizons such as units within the Tertiary, filled alluvial channels, and the contact between top stratum and substratum (gravelly) alluvium. Horizons depicted on the profiles as single lines (solid, dashed, and dotted) were interpreted from seismic profiler records. Horizons depicted as double lines were derived from other data sources such as geologic contour maps, boring logs, and geologic reports. The survey vessel attempted to follow the thalweg, and the subbottom profile survey is nominally a thalweg profile. The channel bottom from subbottom profiler data is not displayed on the interpreted profiles (Figures 7-58). Instead, the computed mean thalweg is shown and represents the channel bottom. The channel bottom is portrayed thus to avoid confusion on the interpreted profiles. Some actual channel bottom reflectors are occasionally displayed in addition to the thalweg where their presence was of interest (for example, the Old Vaucluse Bar channel shown on Figure 8). The channel bottom as profiled and the hydrograph thalweg often do not coincide because four years had elapsed between the hydrograph survey and the subbottom profiling.

Greenville north to Rosedale
(535 to 590 MAHP)

28. Tertiary formations. The segment of river studied from Greenville to Rosedale is characterized by a relatively flat valley floor primarily in Jackson age sediments, probably the Yazoo clay formation. The Tertiary is relatively high in elevation in this segment and is often exposed in the thalweg of the river. Exposures of Tertiary sediments in the river channel as profiled in the survey are hatchured on the maps of Figures 7-58 (for example, see Figure 29). A persistent horizon within the Tertiary sediments was detected and mapped with the seismic profiler continuously from Greenville (538 MAHP) to the mouth of the Arkansas River at 583 MAHP. The horizon may represent the contact between Yazoo Clay and the underlying Moody's Branch marl or the Moody's Branch-Cockfield contact (see Figure 21). A detailed stratigraphic study conducted near Warfield revetment at Greenville by Fisk* indicates that the horizon is most likely the Yazoo Clay-Moody's Branch contact (Figure 11). The contact lies near the top of the Tertiary surface at Greenville (Figures 11 and 14) and then drops in elevation north of Greenville, so that the Yazoo clay is exposed in the valley floor. The contact is a distinct seismic reflector and remains at an elevation of between 0 and -60 ft mean sea level (msl) (about 30 to 90 ft below the top of the Tertiary, which is at about +30 msl) to the vicinity of Caulk Cutoff (575 MAHP), rising again to form the valley floor briefly at Caulk Cutoff. North of 575 MAHP the detailed stratigraphy is less definable. The Yazoo-Moody's Branch contact described above forms a dish-shaped section of a broad, shallow, basin structure about 25 miles in width in the north-south direction. Dips on each flank, measured from the seismic profiles, are on the order of 15 ft/mile. The position of the basin defined by the contact conforms with the mapped position of the Desha Basin (Figure 4) and presumably represents that structural feature. The position of the Tertiary units identified in water wells, engineering borings, and electric logs in the Greenville area is identified in the cross section of Figure 13 at a reduced scale. The Yazoo clay section profiled above 565 MAHP, in the Cypress Bend-Caulk Cutoff area, displays

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* Fisk, H. N. 1943. "Nature of Sediments at Warfield Point," Letter report to the Mississippi River Commission, dated June 12, 1943, Vicksburg, Miss.

stratification that is interpreted as bedding ("contorted bedding" of Figure 31). The bedding is contorted into minor folds of short wavelength and is subparallel to the longer wavelength folding exhibited by the marker horizon beneath it. The latter folding is presumed to be structurally related and the former to be contortions caused by slumping during sedimentation. The stratification detected by the seismic profiler is surprising because the Yazoo clay is generally considered massive. The stratification may be silty or lignitic zones (paragraph 19) or sediment density variations not readily detectable in boring logs.

29. Upstream from the mouth of the Arkansas River the seismic profiler horizons within the Tertiary are less persistent and more difficult to follow. The Yazoo-Moody's Branch contact described above appears to intersect the valley floor at about 583.5 MAHP (Figure 34). Boring control near the river is negligible above Caulk Cutoff, but levee borings drilled to Tertiary depth near Rosedale, about 3 miles from the seismic profile line, logged clay, sandy clay, and sand in the Tertiary sediments, indicative more of the Moody's Branch or Cockfield formations than of the Yazoo clay. Presumably, then, the Yazoo clay suballuvium outcrop north of Lake Providence is limited to the segment between Greenville and the Arkansas River.

30. The Yazoo clay, by nature of its clay composition, is a relatively scour-resistant stratum. It has been incised for only a few feet vertically in several bends north of Greenville, and those areas of exposure are mapped (hatchures) from seismic profile and boring data most extensively in Figures 20, 22, 29, 32, 33, and 35. The greatest exposure of Tertiary strata in the channel bottom occurs in Yellow and Georgetown Bends (550-555 MAHP, Figures 20 and 22). The river at those bends has cut into the Tertiary about 12 ft vertically with subaqueous Tertiary exposure widths of up to 750 ft. The concave bank of Yellow Bend consists of a thin top-stratum of backswamp clays and silts, which offer relatively more resistance to lateral migration of the channel than the more widespread sandy point-bar top strata. The combination of lateral and vertical barriers to river migration at Yellow Bend results in a narrow, asymmetrical, deep channel cross section. Fisk (1947) traced the development of the channel at Yellow Bend from 1913 to 1937. Figure 24 shows Fisk's section modified with data from the latest hydrograph and seismic profile data for 553.7 MAHP. The control exerted by the two scour-resistant deposits is evident on the cross section. A similar situation

exists in Cypress Bend where high Yazoo clay and adjacent backswamp deposits produce another extensive subaqueous exposure of Tertiary sediments in the thalweg similar to Yellow Bend (Figure 29). A high, narrow ridge of Yazoo clay, which resembles a former drainage divide, was mapped at the lower end of Cypress Bend (566 to 568 MAHP) from boring and seismic profile data. Figure 27, the profile for the Cypress Bend segment, shows the probable position of the ridge in 1956 (indicated by boring C-1-56) prior to removal by river scour. A cross section made from boring data and the seismic record at 565.8 MAHP (Figure 30) indicates that the ridge still forms the base of the channel there. The position of the ridge is also expressed in the locally uplifted Yazoo-Moody's Branch contact in the subsurface (Figure 27). The subsurface expression of the ridge in deeper Tertiary sediments implies that the existence of the ridge may be attributed primarily to local tectonic flexure (geologic structure) and secondarily to an erosional drainage divide origin.

31. The subbottom profile clearly identifies and maps the top of the Tertiary (the valley floor) as a continuous, relatively flat and nonincised surface from Greenville north to Rosedale. Borings extending to Tertiary depth along the banks verify the position of the seismic reflector identified as top of Tertiary. Previous mapping of the Tertiary surface in the same area (see Kolb et al., 1968) postulated the presence of a deep entrenched channel beneath the present Mississippi River channel at Tarpley Cutoff (543 MAHP, approximately). The previous mapping presented the best interpretation of the data that were then available, but was based on fewer, more widely scattered borings with no subbottom profiler data, and therefore is less accurate for the areas that were mapped in the current study with the benefit of later borings and seismic data.

32. Alluvial geology. North of Greenville to Rosedale the river meanders in point bar deposits except at Cypress and Yellow Bends where it is cutting into backswamp top strata on the Arkansas side. The channel impinges laterally on clay plugs in several places, e.g., near Rosedale on the Arkansas bank at 588 to 591 MHAP (Figure 40); below the Arkansas River mouth at 583 MAHP on the Mississippi side (Figure 36); at the lower end of Cypress Bend at 567.5 MAHP (Figures 27 and 29), Arkansas side; and in several places at Choctaw Bar, 562 to 563 MAHP, 560 to 561 MAHP, and 557 to 559 MAHP, all on the Mississippi bank (Figures 21, 22, 23, and 26). In addition, the artificial

diversions at Caulk, Ashbrook, Tarpley, and Leland cutoffs have formed plugs that restrict the channel at those locations (Figures 33, 20, 15, and 12).

33. Clay plugs influence and, where frequent, control the course of the meandering Mississippi River by preventing the normal downstream migration of meander loops, causing cutoffs and diverting stream energy elsewhere downstream or vertically into underlying sediments. Therefore, clay plugs are important to this study and are given special attention in this section. Clay plugs develop in abandoned channels formed by neck cutoffs or by chute cutoffs. Neck cutoffs occur when migrating arms of a meander loop meet and form a channel bypassing the loop. The abandonment of the old loop is immediate and the oxbow lake formed by the cutoff fills slowly, primarily with fine-grained material supplied to it during floodwater stages. Clay plugs formed from neck cutoffs consist primarily of clayey silts and clays. Chute cutoffs are formed gradually when the river establishes a new course across swales within the point bar of a meander loop. Chute cutoffs fill initially with sand, with lesser amounts of clay deposited in the former thalweg (Fisk, 1944). Clay plugs are frequent in the modern Mississippi meander belt north of Vicksburg. Within the study area the plugs are most numerous in the Lake Providence Reach (470 to 500 MAHP) and north of Greenville in the Cypress Bend-Choctaw Bar area (555 to 570 MAHP).

34. Borings indicate that the channel invert is well within the substratum sands and gravels in most of the river segment north of Greenville. Seismic reflectors recorded within the alluvium in several stretches surveyed are thought to be either strata with a high percentage of gravel, for example at 564 to 566 MAHP (Figure 27), or remnants of former channels now abandoned, as at 570 MAHP (Figure 31, Note 1) and 548 MAHP (Figure 18, "ORIGINAL BOTTOM, ASHBROOK CUTOFF"). The gravel-type reflector at 564 to 566 MAHP at the upper end of Choctaw Bar (Figures 27 and 30) is irregular in vertical profile and has apparently been severely incised by scour action, which indicates the river is wearing down or sorting the deposit of gravels at Choctaw Bar. This distinct stratum of what appears to be concentrated gravels is draped over the Tertiary ridge discussed earlier in paragraph 30 (Figure 30). The narrow ridge may be directly associated with the deposition of the gravel stratum. Therefore, accurate mapping of the Tertiary ridge may also reveal the position of the more concentrated gravels in this area known to be rich in gravel (Choctaw Bar to Caulk Cutoff).

35. Two distinct alluvial horizons are recorded on the seismic profile at Ashbrook and Tarpley Cutoffs (Figures 18, profile, and 20, map, 14, profile, and 15, map, respectively). The reflector at Ashbrook is recorded between 548 and 549 MAHP at an elevation of 60 to 72 ft msl, which is on a level with the thalweg (Figure 18, labeled "ORIGINAL BOTTOM, ASHBROOK CUTOFF"). The 1937 hydrographic charts (U. S. Army Engineer District, Vicksburg, 1940) show the Ashbrook Cutoff just two years after its construction, and indicate that the bottom of the diversion channel for the cutoff lay at a minimum elevation of 61 ft msl through the cutoff, in that segment of channel where the reflector was mapped by the seismic profiles. It can be concluded from the above data that the river has not cut deeper than the bottom of the original diversion cut since construction of the cutoff (the "ORIGINAL BOTTOM" of Figure 18 does not coincide with the thalweg because the survey vessel crossed the channel, leaving the thalweg, from survey mark 48 to marks 49 and 50, Figures 19 and 20). The river apparently is neither aggrading nor degrading through the cutoff, although it has widened its channel somewhat. A less distinct but similar situation occurs at Tarpley Cutoff (Figure 15). The seismic reflector horizon mapped near 540 MAHP (Figure 14) lies 5 to 15 ft below the original Tarpley cutoff depths charted in 1937 (U. S. Army Engineer District, Vicksburg, 1940). If the reflector is in fact the lower limit of channel scour that occurred after formation of Tarpley cutoff, then the river deepened the cutoff initially to the elevation of the reflector shown in Figure 14 and has since been aggrading in the reach as indicated by the shallow bottom depth of the latest hydrographs.

36. Thalweg slope. The mean thalweg slopes computed for the river profile segments north of Greenville (Figures 14-39) are conspicuously flat to slightly negative with short portions of positive slope. The negative thalweg slopes occur above, through, and below the artificial cutoffs. The positive slopes occur in bends between cutoff reaches. Negative slopes are generally less than -2 ft/mile except for the reach through Ashbrook Cutoff (Figure 18), which displays a thalweg slope of -8.5 ft/mile. Significant segments of positive thalweg slope are present only in Klondike Bend (Figure 39), the bend at Choctaw Bar (Figures 21 and 25), and part of Miller Bend between Ashbrook and Tarpley Cutoffs. Thalweg slopes computed for channel segments plotted in Figures 14-39 are much higher (absolute value) than slopes computed over longer channel segments. High and low thalweg elevations tend to balance out

over a long reach and, therefore, the mean slope computed for long reaches is lower than that for short segments, generally between 0 and 1 ft/mile (absolute value). For example, the mean thalweg slopes for several contiguous plates of this report would have a lower value than that computed for only one plate. The valley slope, computed from 15 minute quadrangle elevation contours that cross the channel, is 0.45 ft/mile for the Greenville to Rosedale segment.

Greenville south to American
Cutoff (535 to 527 MAHP)

37. Tertiary formations. The river abandons its high position atop the flat Tertiary floor of the valley and follows an 85-ft-deep entrenchment to the Greenville bridge (Figures 9 and 10). The marker horizon, interpreted as the Yazoo-Moody's Branch contact and discussed earlier, is undetected on the seismic records below Greenville, and the Cockfield-Jackson Group contact appears to drop in elevation southward according to data from water wells in Mississippi (Taylor and Thomson, 1971) and Arkansas (Figure 9). The identification of the Tertiary units by formation is uncertain, but engineering borings, acoustic data, and hydrologic reports indicate that the Tertiary is of Jackson age, underlain by Claiborne (Cockfield formation). The seismic reflector identified as top of Tertiary is relatively high and flat at about +25 ft msl from Greenville to 532.6 MAHP and then descends to a minimum elevation of -53 ft msl at 532 MAHP, north of the Greenville bridge. The deep channel (in the Tertiary surface) is near the mapped position of the old meander loop that now forms Lake Chicot to the west (Clay Plugs of Figure 10). Fisk (1947) (his Plate 55) states that Lake Chicot was formed by a neck cutoff during his Stage 14 of Mississippi River history around 1500 A.D. However, the deep channel interpreted from the seismic profile is apparently too deep to have been cut by Fisk's Stage 14 channel, which had an invert elevation of not lower than +15 ft msl, and must instead represent an entrenched channel cut prior to or after Stage 14 and probably not related to the channel that formed Lake Chicot.

38. Alluvial geology. The short river segment south of Greenville lies in point bar silts and sands and appears to be influenced primarily by one feature, the Lake Chicot abandoned channel near the Greenville bridge (Figure 10). The "wall" of resistant silty clays and clays formed by the plugged abandoned Lake Chicot channel at 541.5 to 532.5 MAHP on the Arkansas

side diverts the present channel to the southeast and causes it to cut deeply into the Tertiary Jackson units against the west bank. Indeed, the deep (-53 ft msl) channel upstream of the bridge (Figure 9) appears to have been formed because of the presence of the Lake Chicot plug, in which case the deep channel is a product of the present river course. The thickest vertical section of clay plug lies within the western portion of the abandoned channel shown on Figure 10, and so the plug should remain a barrier to lateral migration for a long time (Fisk, 1947, his Plate 55, Section B-B').

39. Other alluvial features mapped with the seismic profiler are the recently abandoned back channel of Walker Bend (lower end of Vaucluse Bar) and the apparent top of the gravelly alluvium. The abandoned back channel was profiled near its mouth and is shown, on Figure 9, at survey marks 12 to 13, to be filled with two sequences of finely bedded sediments. The bottom of the back channel lies at +31 ft msl, about the same as the abandoned channel of Lake Chicot. The reflector representing what is thought to be the top of the gravel-bearing substratum is a rough, irregular, hummocky but fairly flat-lying horizon that lies from 0 to 25 ft below the thalweg of the river (533 MAHP of Figure 9). No samples were taken of bottom material during the seismic survey and it is not certain that the reflector actually represents the top of the substratum.

40. Thalweg slope. The channel slope in this short segment of the river is controlled by the deep scour pool near the Greenville bridge. The thalweg drops at a gentle pace through Greenville (4.2 ft/mile, Figure 9), plunges rapidly to the deep hole north of the bridge (Figure 9) and becomes negative (-2.8 ft/mile) south of the bridge toward American Cutoff (Figure 7). The valley slope computed from 15 minute topographic quadrangles is 0.38 ft/mile for this segment.

Lake Providence (468 to 504 MAHP)

41. Tertiary formations. The segment of the river studied in the Lake Providence area includes the lower end of Sarah Cutoff; the Lake Providence Reach, the long relatively straight channel from Opossum Chute to Hagaman revetment; the big bend at Fitler Bend; and Cottonwood Bar. The Tertiary surface topography is very irregular from the north end of Fitler Bend through Lake Providence to Opossum Chute, with as much as 120 ft difference in elevation in a short distance. The Tertiary reflector is difficult to follow in that portion of the survey (Figures 46-56). From the upper end of Fitler Bend

(476 MAHP) southward, the top of bedrock is flat, distinct, and easily mapped from the seismic records (Figures 41 and 43). The Tertiary seismic reflectors in the Fitler Bend-Cottonwood Bar area (south of 476 MAHP, maps, Figures 45, 44, 42, and profiles, Figures 43 and 41) are strikingly similar in appearance and character to those in the segment of river north of Greenville, i.e., they resemble the Yazoo clay-Moody's Branch sequence (see paragraph 26). The contorted bedding within the Tertiary in the Fitler Bend seismic records (Figure 43) resembles the bedding of the Yazoo clay at Cypress Bend (Figures 27 and 31). In addition, a lower strong Tertiary reflector, identified on Figures 41 and 43 as the contact between Jackson and Cockfield, is present in the Fitler Bend records that correlates with the deep, persistent horizon mapped and identified from Greenville north to Caulk Cutoff as either the Jackson Group-Cockfield contact or the Yazoo clay-Moody's Branch contact (Figures 21-34). These similarities in seismic reflector characteristics and the lithology of the Tertiary sediments logged in engineering borings (commonly CH) in the Fitler Bend area mark the Tertiary underlying the alluvium at Fitler Bend as Yazoo clay-Moody's Branch. That interpretation agrees with Fisk's position for the Jackson Group-Claiborne Group contact south of Lake Providence (Figure 4).

42. The Tertiary horizons change in character upstream of 476 MAHP because the Claiborne (Cockfield formation) apparently rises in elevation on the southern flank of the Monroe uplift where it forms the valley floor throughout the Lake Providence Reach. The seismic reflectors were lost on the profile records between 476 and 478 MAHP because of the presence of a seismically impenetrable, thick shoal (Figure 43). However, a reflector was mapped from the seismic records from 478 to 478.5 MAHP, that may represent the ascending Jackson Group-Cockfield contact (contact labeled on Figures 43 and 46). Figure 46 illustrates the complex configuration of the seismic reflectors mapped through the Hagaman revetment area. Deep boring control is sparse near the river and labeling of the many reflectors is difficult, but it appears that the top of the Tertiary lies deep (60 to 100 ft) below the channel bottom upstream of mile 480 and that the Tertiary is Cockfield (reflector A of Figure 46). The deepest part of the entrenched valley apparently lies between 480 and 481 MAHP where it attains a minimum elevation of about -105 ft msl. A reflector (B of Figure 46) above the deep entrenched valley occurs at an elevation of -37 to -67 ft msl. Although not identified on Figure 46, the

reflector may represent the actual top of the Tertiary in Yazoo clay (Jackson Group) underlain by the Cockfield formation contact (reflector A) below at about -90 to -105 ft msl. Fisk's geologic map (see Figure 4) shows a suballuvium exposure of the Jackson Group at around 480 MAHP. In plan view, the present river channel runs parallel and close to the probable strike of the Jackson-Claiborne contact between 478 and 483 MAHP and it would not be unusual to see Jackson units reoccurring along the thalweg line. One or two deep borings (to approximate elevation -120 ft msl) near the bank between 480 and 484 MAHP would be necessary to label the reflectors confidently.

43. The position of the top of the Tertiary shown on Figures 46 (upstream of 483 MAHP) through 56 (to 503 MAHP) was not continuously detected on seismic records for the entire segment. Lack of penetration through river sediments in a few places and the incised nature of the valley floor make it difficult to follow the Tertiary reflector through the Lake Providence Reach. Only where boring data occur very close to the survey line is the Tertiary labeled confidently. Where seismic data gaps exist, the geologic quadrangle Tertiary surface contours are used to position the top of the Tertiary (Smith, 1979). There is disagreement between the geologic quadrangle contours and the seismic data regarding the position of the deep channel of the entrenched valley at approximately 491 MAHP. The geologic quadrangle for Lake Providence shows a deep (below -100 ft msl) channel crossing beneath the present river at 491 MAHP. The seismic reflector mapped as the top of Tertiary on Figure 51 of this study shows no deep channel at mile 491. The presence of deep channels near 491 MAHP is indicated in area borings. For example, in boring BY-19 (Figure 52) the top of the Tertiary is logged at -88 ft msl. The deep cuts may be part of a main entrenched channel in the Lake Providence Reach or portions of headward eroding side channels of the entrenched valley that are not continuous and persistent throughout the reach. However, the presence of a deep channel at 500 to 501 MAHP (Opossum Chute) is verified by all available data as shown on Figure 56. Local borings log Tertiary as deep as -95 ft msl and the mapped seismic Tertiary reflectors drop below detectable depths between 500 and 501 MAHP, indicating a deep channel there.

44. Little or no bedding within the Tertiary units was noted in seismic profile data for the Lake Providence Reach south of Opossum Chute (501 MAHP, Figure 56). From 501 MAHP upstream to 503 MAHP, however, the top of Tertiary is relatively high and flat compared to that downstream, and the seismic

records show a great deal of thin persistent bedding within the Tertiary to a depth of at least 45 ft below top of Tertiary (elevation +12 to -33 ft msl, Figure 56). There appears to be some structure in the form of folds and faults, or stratigraphic unconformity associated with the thin bedding. The character of the profile data in this 2-mile segment is unique when compared with the other data from the 100 miles of river surveyed. Boring 4-67U of Sarah Island revetment, located 600 ft from the profile line (Figure 57), logs the Tertiary as a clayey sand, which agrees with the designation of Tertiary units in the Lake Providence Reach as the Cockfield formation. The strata represented by the fine bedding may be those of a stratigraphically lower part of the Cockfield formation than that seen elsewhere in the study area, implying that the position of greatest upward movement within the Monroe uplift, the axis, crosses at or northward of the Opossum Chute area. That observation agrees with the position of the axis on the geologic map of Figure 4. The seismic profiling did not extend upriver far enough to trace the occurrence of the finely bedded strata.

45. The thalweg of the present Mississippi River is cutting into Tertiary material only locally in the Lake Providence area. At Fitler Bend, subaqueous exposures of Tertiary occur in long narrow zones between 476.4 and 474.6 MAHP (Figure 45) and between 474 and 473 MAHP (Figures 42 and 44). Depth of penetration by the river into Tertiary is less than about 7 ft vertically. Other short segments of Tertiary exposure occur at 502 MAHP (Figure 57) and 503 MAHP (Figure 58) where the river cuts about 6 ft vertically into the Tertiary. The top of the Tertiary in the Lake Providence Reach characteristically lies well below the channel bottom beneath a thick blanket of alluvium as illustrated in Figure 53, a section across the channel at 494 MAHP constructed from the acoustic profile data and boring logs.

46. Alluvial geology. The Mississippi flows within generally noncohesive point bar and swale top strata in this segment of the valley as identified on the geologic quadrangles for Alsatia and Lake Providence (Smith, 1979). The banks are primarily in silts and sands, but several clay plugs that confine the river are present in the Lake Providence Reach. Boring logs penetrating the alluvium in the study area indicate that the present thalweg lies generally above the gravelly substratum in the Lake Providence Reach between 480 and 500 MAHP. The bends upstream and downstream of the reach at Opossum Chute and Fitler, respectively, cut down through the substratum into the Tertiary.

47. Clay plugs are numerous in the Lake Providence area and have been mapped previously (Smith, 1979). Plugs make up the banks in several places as shown on Figures 42 (473 MAHP), 45, 48, 50, 52, 55, 57, and 58. Clay plugs occur near both banks of the river between 491 and 495 MAHP (Figures 52 and 55) and confine the channel, preventing it from meandering and helping to produce the straight shallow reach at Lake Providence. Straight reaches are characteristically shallow. Quoting Friedkin (1947-48):

> In the bends, triangular-shaped cross sections develop with the point of greatest depth along the concave bank. Such cross sections develop here because the alignment tends to direct and concentrate the flow against the concave bank along which the incident scouring forces develop a relatively deep channel. . . . Crossing over from one bend to the next through usually a short tangent the flow, lacking concentration against a bank, spreads into a . . . wide cross section. As a consequence, the sand-carrying capacity of the flow is considerably less in the crossings than in the bends. . . . The long, nearly straight reaches are usually the most troublesome for navigation. As previously discussed, the cross sections are generally wider and hence more shallow than in other reaches of the river, and the flow is often divided by middle bars. These channel characteristics appear to be directly attributable to the type of alignment--the lack of curvature. In contrast to the bend sections where the flow is directed toward and concentrates against the concave banks and where the sand deposits in a somewhat orderly fashion on the convex shore, in the straight reaches the high flows are dispersed over the entire width and the sand deposits and shifts in a haphazard manner.

The lack of curvature in the Lake Providence Reach, a consequence of the presence of clay plugs in the reach, is one explanation for its shallow cross sections, tendency to shoal, and recognized increased flood profile.

48. The seismic profiler detected reflectors interpreted as abandoned channels at 481 to 482 MAHP and 483 MAHP (Figure 46, Notes 1 and 2) and 488 MAHP (Figure 49, Note 1). Small, relatively insignificant backfilled channel-like reflectors that appear to be cut into the Tertiary were detected at 497 MAHP ("Alluvium-filled channel" of Figure 54), and just downstream of 502 MAHP ("Tertiary channels" of Figure 56). The small Tertiary surface channels are thought by the author to be local, short incised tributaries to the main channels of the entrenched valley. The broad channel-like reflector at 483 MAHP (Figure 46, Note 2) occurs at the mouth of the abandoned Hagaman

channel, now the entrance to the Port of Lake Providence. The invert elevation of the reflector is -15 ft msl, which is deeper than any channels charted on hydrographs dating back to 1937. Presumably, the seismic reflector represents an older channel formed before the reach began shoaling.

49. The seismic reflector at 488 MAHP (Figure 49, Note 1) is prominent on the seismic records. The reflector lies at an elevation of +18 to +27 ft msl in a map position that places it within the position of old Stack Island and also within the position of the eastward extension of the former channel that now forms the oxbow Lake Providence (Position marks 39 and 40, Figure 50). Fisk's (1947) Plate 63 shows several boring-controlled cross sections constructed across the abandoned channel of Lake Providence. The invert elevation of the abandoned channel is about +20 ft msl on the cross sections and conforms to the elevation of the seismic reflector. Accordingly, the reflector on Figure 50 could be interpreted as the bottom of the ancient Lake Providence loop. Another interpretation is that it represents the remains of some natural or man-made structure associated with old Stack Island.

50. The profiles for the Lake Providence area plotted on Figures 41 through 56 show other seismic reflectors that occur within the alluvium above the interpreted top of Tertiary. Many reflectors are unlabeled for lack of positive identification but are included in hope they can eventually be interpreted from subsequent information. Two reflectors in the alluvium merit discussion. The first reflector is between 472 and 473 MAHP in Fitler Bend ("Reflector in alluvium" of Figure 41). A distinct horizon with a prominent scarp on the upstream side occurs atop the Tertiary reflector about 1200 ft from the left bank (Survey Mark 8 on Figure 42). The reflecting horizon is covered with about 15 ft of sediment and is accompanied by a shoal on the river bottom where it occurs. The reflector is about 2000 ft upstream of the mapped position of the old Fitler revetment (Figure 42), which has been overrun by the eastward migration of the river at Fitler Bend. The horizon does not occur on seismic profiles run nearer the left bank (e.g., at Mark 15, Figure 42), and is interpreted to be associated with or part of the old Fitler revetment, even though its position is somewhat upstream of the mapped position of the old revetment.

51. The second reflector is the abrupt shoal that runs for about 2 miles just upstream of Lake Providence from 491.5 to 493.5 MAHP (Figures 51 and 52). The shoal (high channel bottom) was plotted on the 1973-75 hydrograph as

indicated on the thalweg profile of Figure 51. The seismic data characterize the shoal as an acoustically impenetrable but relatively "soft" material, because few bottom multiple images of the reflector occur on the seismic record. The shoal material is probably a poorly compacted, air-entrained silty or clayey sediment perhaps derived in part from caving banks that are now partially protected by the Baleshed-Stack Island revetment. Comparison of 1964 and 1975 hydrographs indicates that the right bank has retreated as much as 800 ft in the interim period between 491.5 and 493.0 MAHP. Logs of revetment borings L-28-64 through L-34-64, drilled in 1964 (Figure 52), identified the upper 30 ft or more of the right bank in this area as clays, silts, and silty sand. Those soil types, eroded from the caving right bank, probably form the shoal of 491.5 to 493.5 MAHP. The inability of the river to move its load through the Lake Providence Reach, and the tendency of the channel to shoal, is dramatically verified by the fact that the shoal was relatively unchanged in the four years between the last hydrographic survey and the seismic profile survey. Although not shown on the profile of Figure 51, the channel bottom as profiled (1979) coincided with the thalweg profile (1975) for the shoal.

52. Thalweg slope. The Lake Providence Reach is notable for its long stretch of negative thalweg slope indicative of a channel aggrading its bed. From 498 MAHP above Mayersville (Figure 55) to 482 MAHP below Lake Providence (Figure 48), the mean thalweg slope is -2.2 ft/mile for those 16 miles. The local thalweg slope for the segment of channel represented in Figure 49 is -7.9 ft/mile, the highest in the straight reach. Below the Lake Providence reach the slope remains negative through Fitler Bend and Cottonwood Bar, as high as -8.6 ft/mile at Cottonwood Bar (Figure 41). The valley slope computed from 15 minute quadrangles is 0.42 ft/mile for this segment.

Summary of Study Segment Characteristics

53. The segments of the Mississippi River surveyed were compared on the basis of the position and composition of the Tertiary formations underlying the alluvium, the distribution and types of alluvial deposits, and the valley slope. Table 1 summarizes the characteristics of the three study segments. The study segment from Greenville north to the Arkansas River lies within the Desha Basin and is characterized by a relatively high flat valley floor with

sediments of Jackson age outcropping in the channel. Top of Tertiary is easily mapped by the subbottom profiler in this segment. Tertiary sediments are exposed extensively in the meander bends and affect the migration of meanders and the depth of downcutting because of the Yazoo clay's resistance to scour. Subaqueous outcrops of Tertiary sediments attain widths as great as 750 ft and exposed thicknesses of 12 ft. South of Greenville to American Cutoff, the valley floor is deeply incised by an entrenched channel of the Mississippi but apparently still is composed of Jackson age sediments because the Jackson-Claiborne contact dips to the south from Greenville.

54. The study segment through the Lake Providence Reach, which includes Opossum Chute north of the reach and Fitler Bend-Cottonwood Bar south of the reach, is characterized by the presence of the Cockfield formation on the valley floor upstream of Fitler Bend. The valley floor is severely incised by deep entrenched channels and lies well below the thalweg depth of the present Mississippi channel throughout the straight portion of the reach. From Fitler Bend south, the underlying Tertiary units strikingly resemble the Tertiary sequence north of Greenville in boring logs and in subbottom profile signatures. The two Tertiary occurrences are interpreted to be equivalent stratigraphically and to represent the Yazoo clay-Moody's Branch formations. Jackson and Claiborne units possibly interplay in the channel segment between Fitler and Lake Providence to form a complex subsurface geologic picture that is difficult to interpret from acoustic profiles alone. The Tertiary units of the valley floor in the Opossum Chute-Sarah Cutoff segments north of the reach are acoustically dissimilar to any other Tertiary units detected in this study and are interpreted to be stratigraphically deeper Cockfield units exposed near the crest of the Monroe uplift, the controlling geologic structure in the Lake Providence area.

55. The Greenville-Rosedale segment and the Lake Providence segment are similar regarding the nature of alluvial deposits encountered by the river. Clay plugs are numerous in both segments (Table 1). The Greenville to Rosedale channel encounters fine-grained backswamp in Cypress and Yellow Bends that interacts with shallow resistant Tertiary to create steep, narrow channel cross sections in those bends. The thalweg of the Greenville-Rosedale channel is well entrenched in the substratum sands and gravels. The Lake Providence channel, however, flows only in generally noncohesive point bar top strata above the substratum gravelly sands and encounters no backswamp or Tertiary

soils upstream of Fitler Bend. The Lake Providence Reach has not formed sharp bends and therefore the channel is characteristically broad and shallow. Concentrations of gravel deposits were interpreted from acoustic profile records from Choctaw Bar northward.

56. The percentage of riverbank encountering clay plugs, computed as the ratio of cumulative length of clay plug in the banks to total bank length (Table 1) is identical for the Greenville and Lake Providence segments. However, there are additional clay plugs in the Lake Providence Reach that lie outside the present banks, landward of now abandoned channels in this divided flow reach that were not included in the computation (e.g., the plugs on the Louisiana side behind Old Hagaman revetment near Lake Providence (Figures 48 and 50)). Clay plugs probably played a more important role in the historical development of the Lake Providence Reach than they do now because attempts have been made to channelize the reach by construction of dike fields and revetments.

57. Sinuosity was computed for the Greenville-Rosedale segment and the Lake Providence segment. The Greenville-American Cutoff segment was too short to determine sinuosity. Sinuosity was computed as the channel distance determined from river miles divided by the valley distance as determined from 1:250,000 topographic maps. Present-day (postcutoff) sinuosities for the two segments are similar (Table 1) at 1.38 for Greenville-Rosedale and 1.44 for Lake Providence. Precutoff sinuosity for the Greenville-Rosedale segment, however, was 2.20 as computed from the old river-mile data on the 1930-32 survey (Mississippi River Commission, 1938). Because of the contrast between precutoff and postcutoff sinuosities, comparison of reaches to determine effects of local and regional geologic conditions on sinuosity obviously will have to be performed for precutoff channel mileages.

58. Thalweg slopes computed for the survey segments are generally flat to negative. Negative slopes were expected in the Lake Providence Reach, known to be shoaling its bed, but were surprising in the Greenville-Rosedale segment where the stream gradient had been steepened locally by the cutoffs. The maximum thalweg depth may be limited above Greenville by the high, flat resistant Yazoo clay on the valley floor. In the Lake Providence Reach, the downcutting seems to be limited at least in part by a lack of meanders which have been constrained by the presence of clay plugs in the banks. Valley slope, computed from contours on 15 minute topographic quadrangles, are

similar for the 55-mile-long Greenville-Rosedale segment and the 36 mile-long Lake Providence segment, 0.45 ft/mile and 0.42 ft/mile, respectively.

PART V: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

59. The acoustic subbottom profiler is an effective exploration tool for geologic and engineering investigations in the Mississippi River. The top of the Tertiary comprising the valley floor, and units within the Tertiary, were traced continuously for several miles through as much as 100 ft of overlying alluvial sediments. The attitude and position of the Tertiary surface was identified and mapped from acoustic records in much of the channel. Subaqueous exposures of the Tertiary in the channel were mapped using acoustic profile data and hydrographic charts. Subbottom profile records refuted or verified some horizons that previously had been mapped only by correlating between borings. Structure and bedding in Tertiary sequences were delineated on some of the profile records. The subbottom profiler detected many horizons within the Recent alluvium, some of which are readily identified from hydrographs and maps of former channel courses, and others that require subsurface sampling to formulate or verify their interpretation.

60. Tentative conclusions drawn regarding the influence of geologic features on behavior of the Mississippi River in the study areas are:

- a. The north-south lineation that is the Mississippi structural trough has probably determined the general course of the lower Mississippi River by acting as a zone of weakness for the river to follow, much as faulting controls alignment of smaller streams.
- b. Other structural features, the Monroe uplift to the south and the Desha Basin to the north, create the major difference in geologic regime between the Greenville-Rosedale study segment and the Lake Providence segment by exposing sandy, more erodible Cockfield sediments on the valley floor beneath Lake Providence and more resistant Jackson sediments, predominantly Yazoo clay, beneath the Greenville-Rosedale area.
- c. Locally, a combination of resistant Yazoo clay in the channel thalweg and clayey, silty backswamp strata in the top bank results in a deep, narrow asymmetric channel cross section at two locations between Greenville and Rosedale--Yellow-Georgetown Bend and Cypress Bend. Backswamp top strata inhibit lateral movement in the top bank and cohesive Yazoo clay maintains a steep slope in the thalweg, preventing lateral movement in the deep part of the channel. Analysis of the acoustic profile and boring data shows clearly the occurrence of the resistant strata in the study areas.

d. The straightness of the Lake Providence Reach is partially attributable to the abundance of clay plugs there, which constrain lateral stream cutting and forestall meandering, thereby preventing high flow velocities and resulting in deposition and aggradation in a broad, shallow channel cross section.

Recommendations

61. Geologic investigation using the acoustic subbottom profiler should be continued for other reaches and segments of the Mississippi River within the Vicksburg District. Top of Tertiary, geologic structure, and stratigraphy for the remaining segments should be mapped by correlating acoustic data and available boring data, including engineering boring logs and geophysical logs of water wells in the floodplain, the latter cataloged by and available from state geological surveys. At the same time, alluvial features of the valley fill, especially those that might influence channel geometry and meander pattern of the river, should be mapped. During the course of surveying and mapping the remaining river segments, comparisons should be made between segments and with previously mapped segments so that similarities, anomalies, and differences can be analyzed and incorporated into the overall Vicksburg District Potamology Program.

62. Allowance should be made in future acoustic subbottom investigation for simultaneous sampling of bottom sediments and for a follow-up boring program to verify and/or sample key subbottom horizons detected in the acoustic profiles. Borings should be capable of penetrating as much as 150 ft and should be placed as near the survey line as possible, and in some cases may require being drilled within the channel. A boring and sampling program not only will allow verification and identification of actual acoustic reflectors, but will also result in much being learned of the relationship between acoustic signatures and the physical properties of the sediments being encountered.

63. Grain size analyses of Mississippi River floodplain deposits indicate much overlap of grain sizes between the various depositional environments. Other characteristics of the deposits, such as thickness, shape, and angle of attack by the stream, should be investigated regarding resistance to scour and perhaps less emphasis placed on grain size.

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Table 1

Comparison of Study Segments

	Characteristics of the Tertiary					Alluvium		Valley Slope		
River Segment	Formation	Lithology	Erodibility	Overburden* ft	Outcrop** percent	Clay Plugs† percent	Backswamp†† percent	Segment Length miles	Valley Slope ft/mile	Sinuosity
Greenville-Rosedale (535-590 MAHP)	Yazoo Clay‡	Typically CH	Low	0-50	20	9	4	55	0.45	Precutoff = 2.20 Postcutoff = 1.38
Greenville-American Cutoff (527-535 MAHP)	Yazoo Clay	Typically CH	Low	5-55	0	6	0	8	0.38	—
Lake Providence (468-504 MAHP)	Yazoo Clay‡‡ Cockfield §	Typically CH Clay, sandy clay, sand	Low High§§	0-140	8	9#	1	36	0.42	1.44

* Thickness of alluvium between top of *Tertiary and channel thalweg* (*i.e.*, depth to Tertiary).

** Ratio, cumulative length of Tertiary exposed in channel to total channel segment length.

† Ratio, cumulative length of clay plugs exposed in bank to twice total channel segment length.

†† Ratio, cumulative length of backswamp exposed in bank to twice total channel segment length.

‡ Tertiary strata north of Arkansas River mouth may be older Moody's Branch or Cockfield, which are sandier strata.

‡‡ Mile 478.5 to 468.

§ Mile 478.5 to 504.

§§ Erodibility relative to these two formations.

\# Includes only those clay plugs in present channel bank. Other plugs in area but behind levees or otherwise isolated from channel.

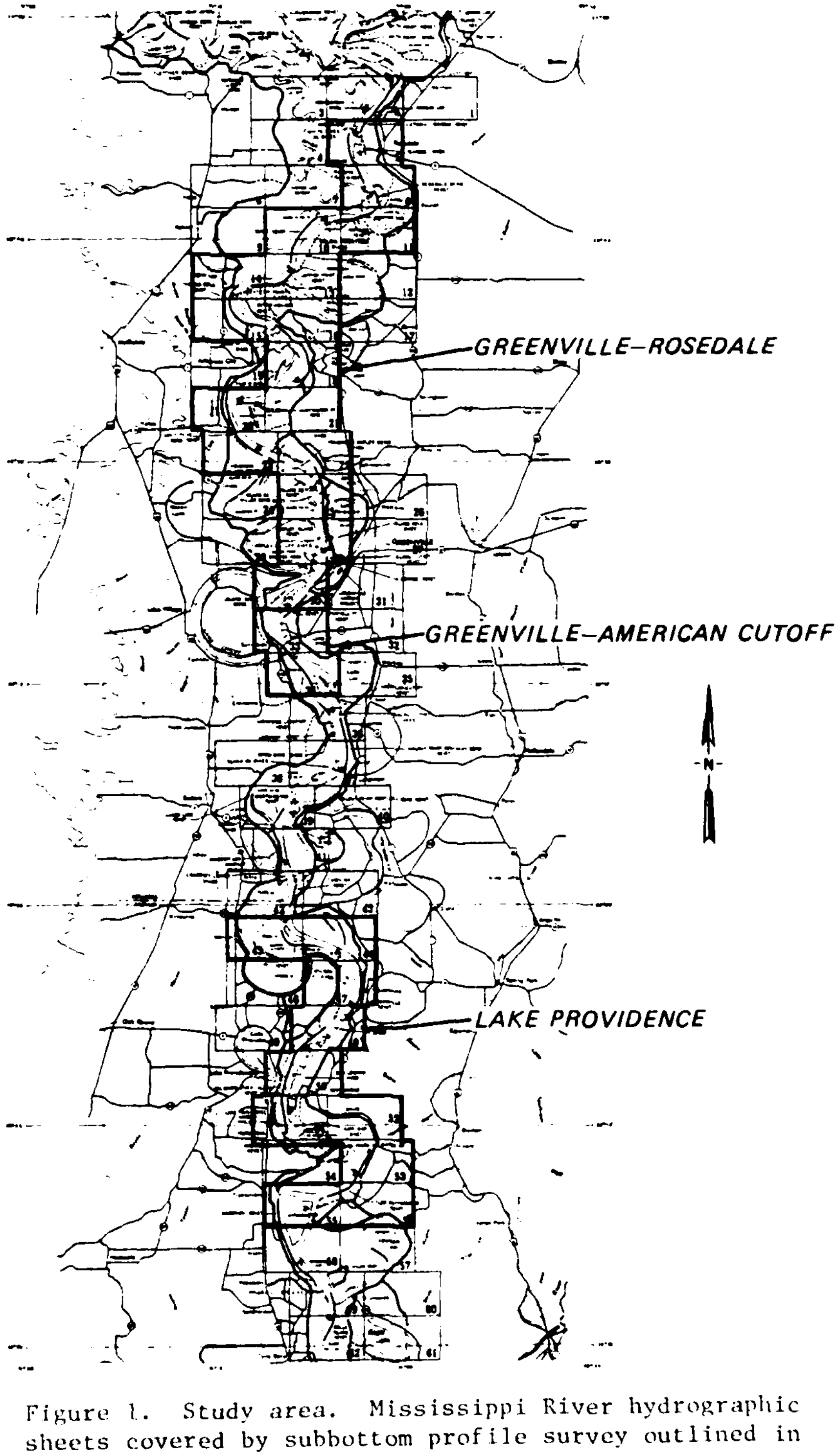


Figure 1. Study area. Mississippi River hydrographic sheets covered by subbottom profile survey outlined in heavy border

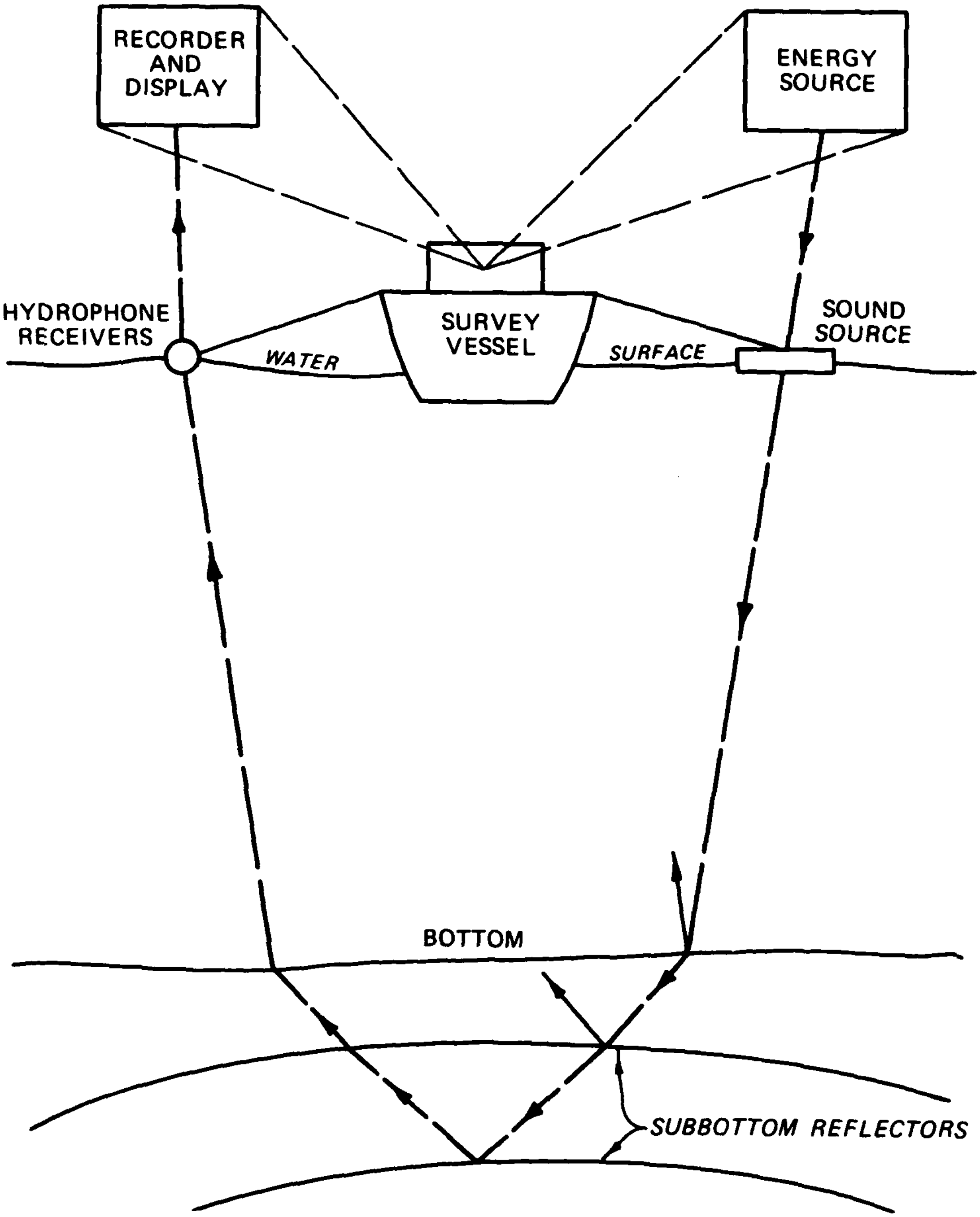


Figure 2. Elements of continuous acoustic subbottom profiling technique

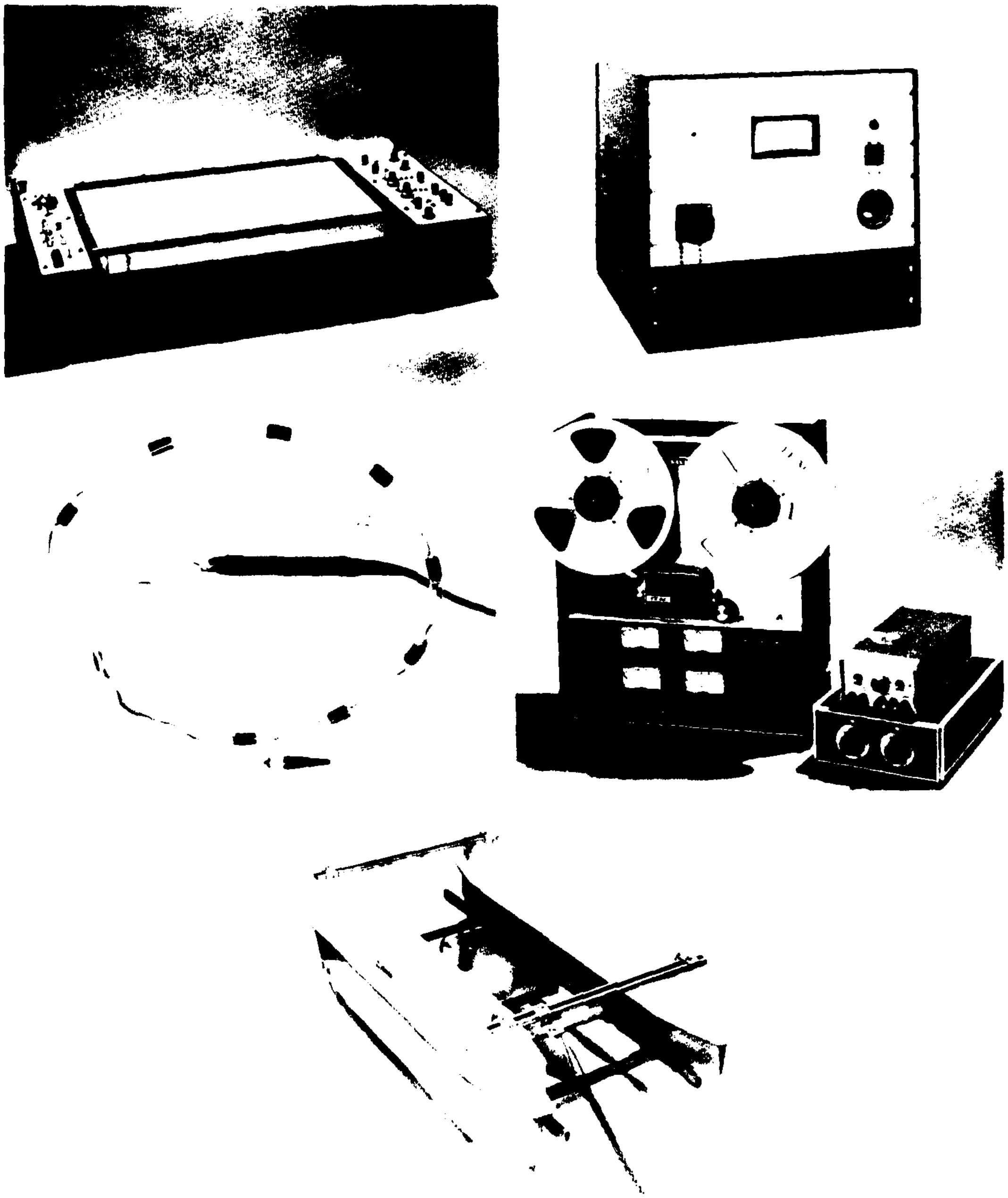


Figure 3. Equipment for continuous acoustic subbottom profiling system used by the Waterways Experiment Station. Clockwise from upper right: energy source, tape recorder and amplifier filter, catamaran-mounted transducer (sound source), hydrophone cable, graphic recorder

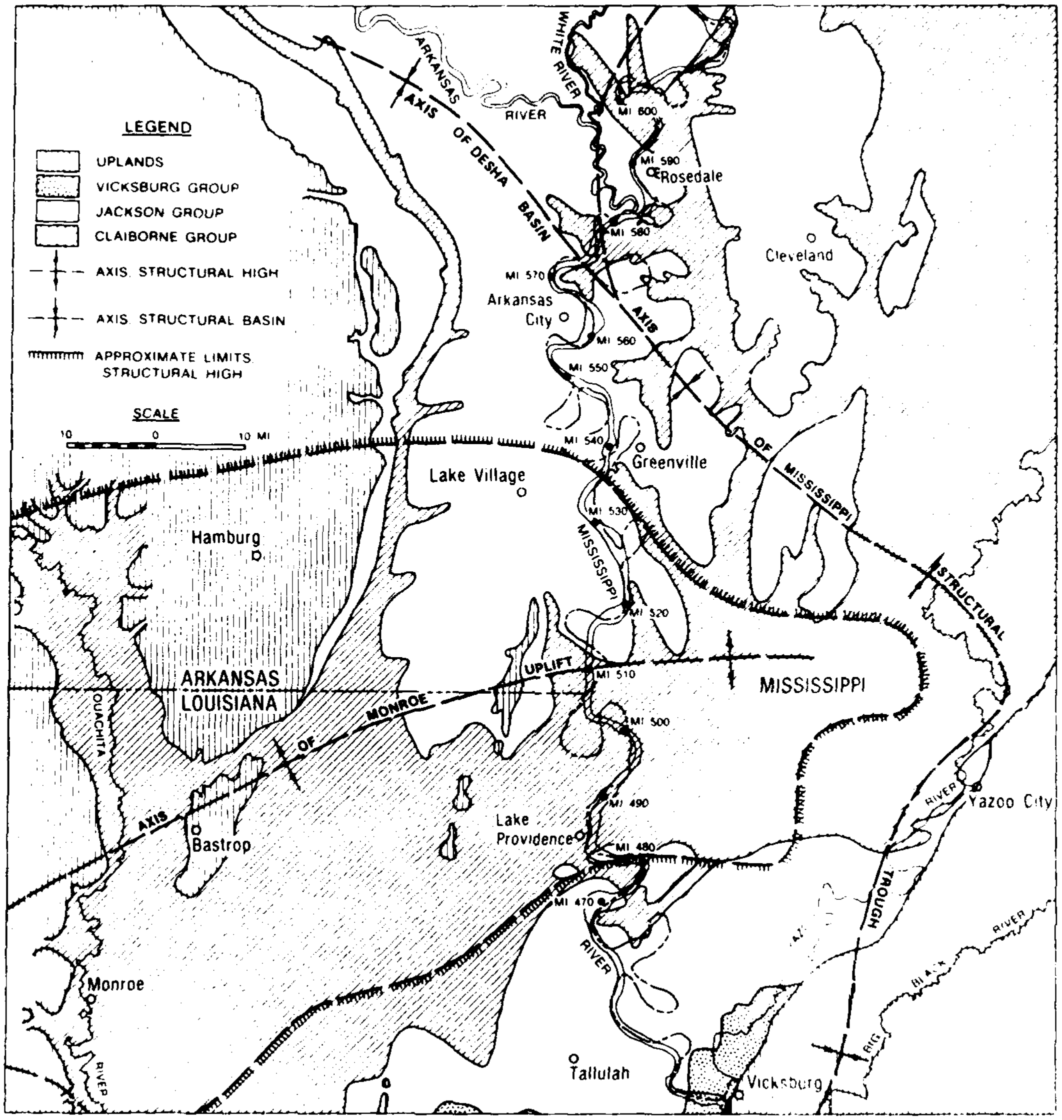


Figure 4. Geologic map of mid-lower Mississippi River valley showing sedimentary units on valley floor underlying the alluvial fill (after Fisk, 1944; structural data from Fisk, 1944, Taylor and Thomson, 1971, and U. S. Geological Survey and the American Association of Petroleum Geologists, 1962)

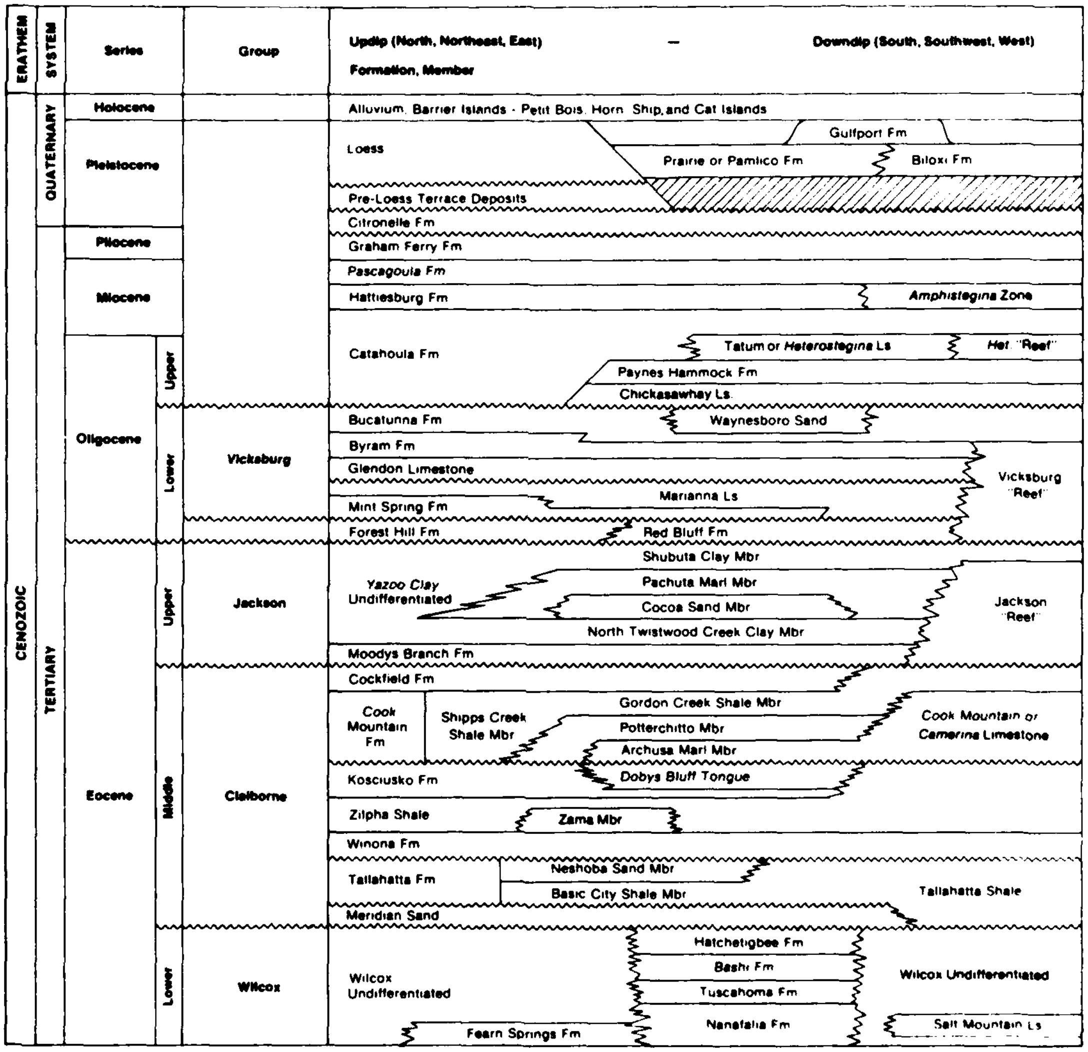


Figure 5. Partial stratigraphic column of Mississippi, showing the sediments of the Mississippi River valley (from Dockery, 1981)

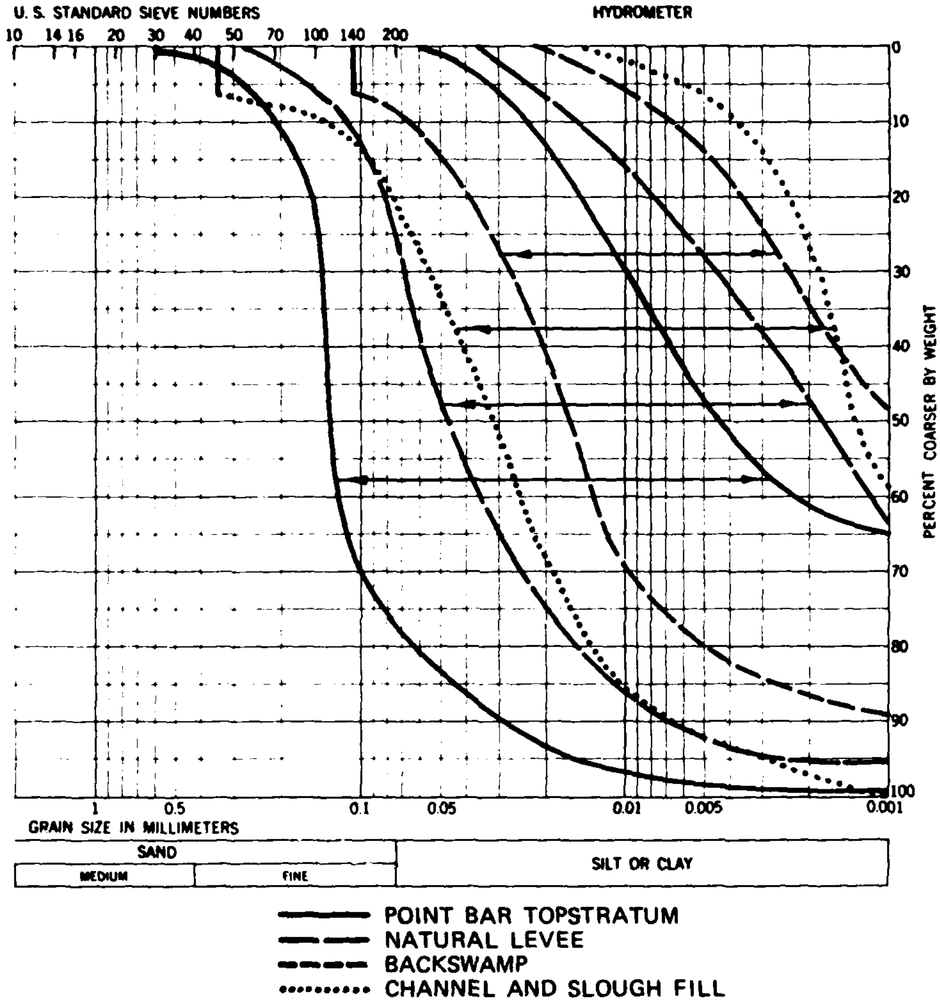


Figure 6. Range of grain-size distribution curves for Mississippi River top strata (from Fisk, 1947)

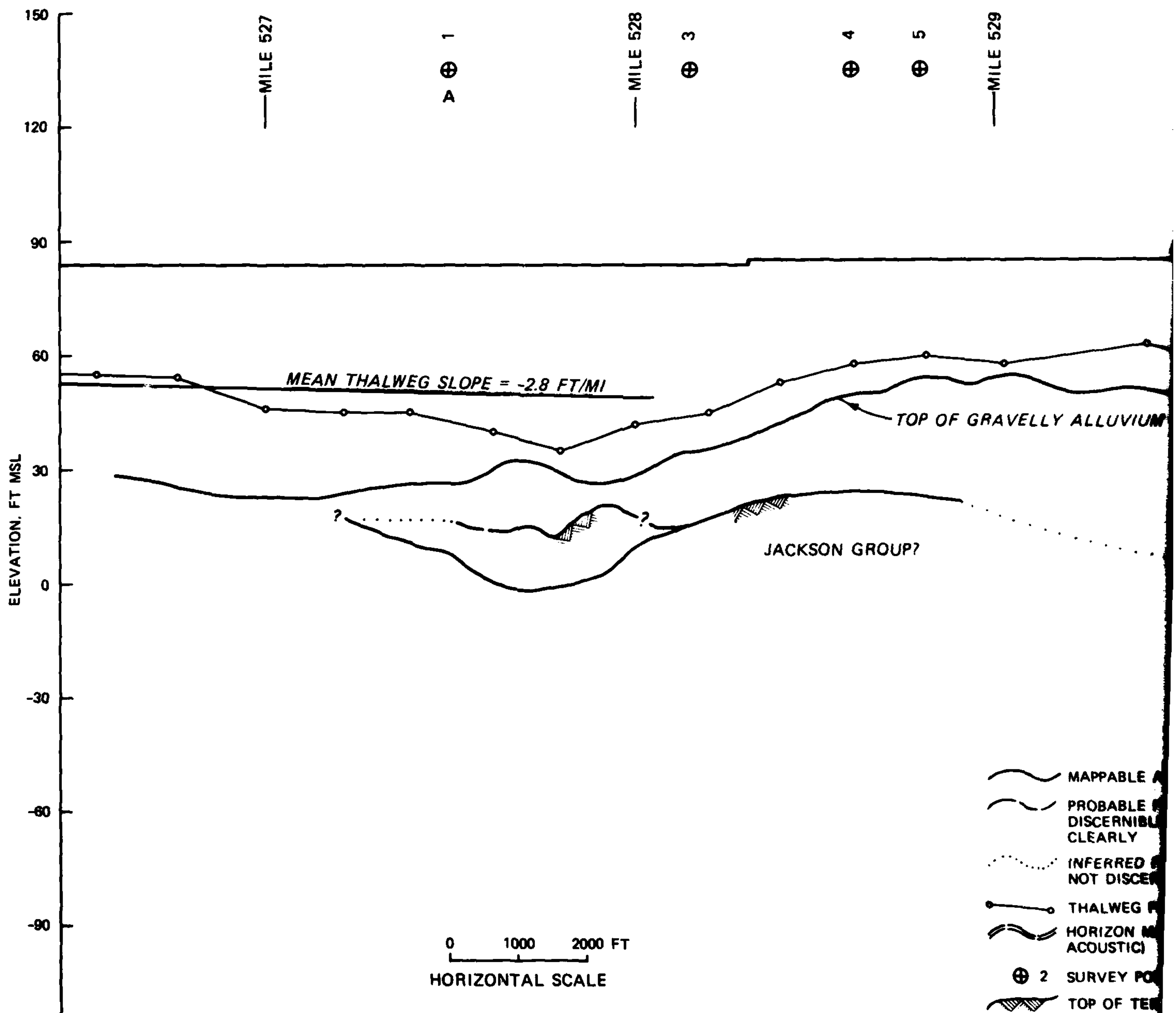
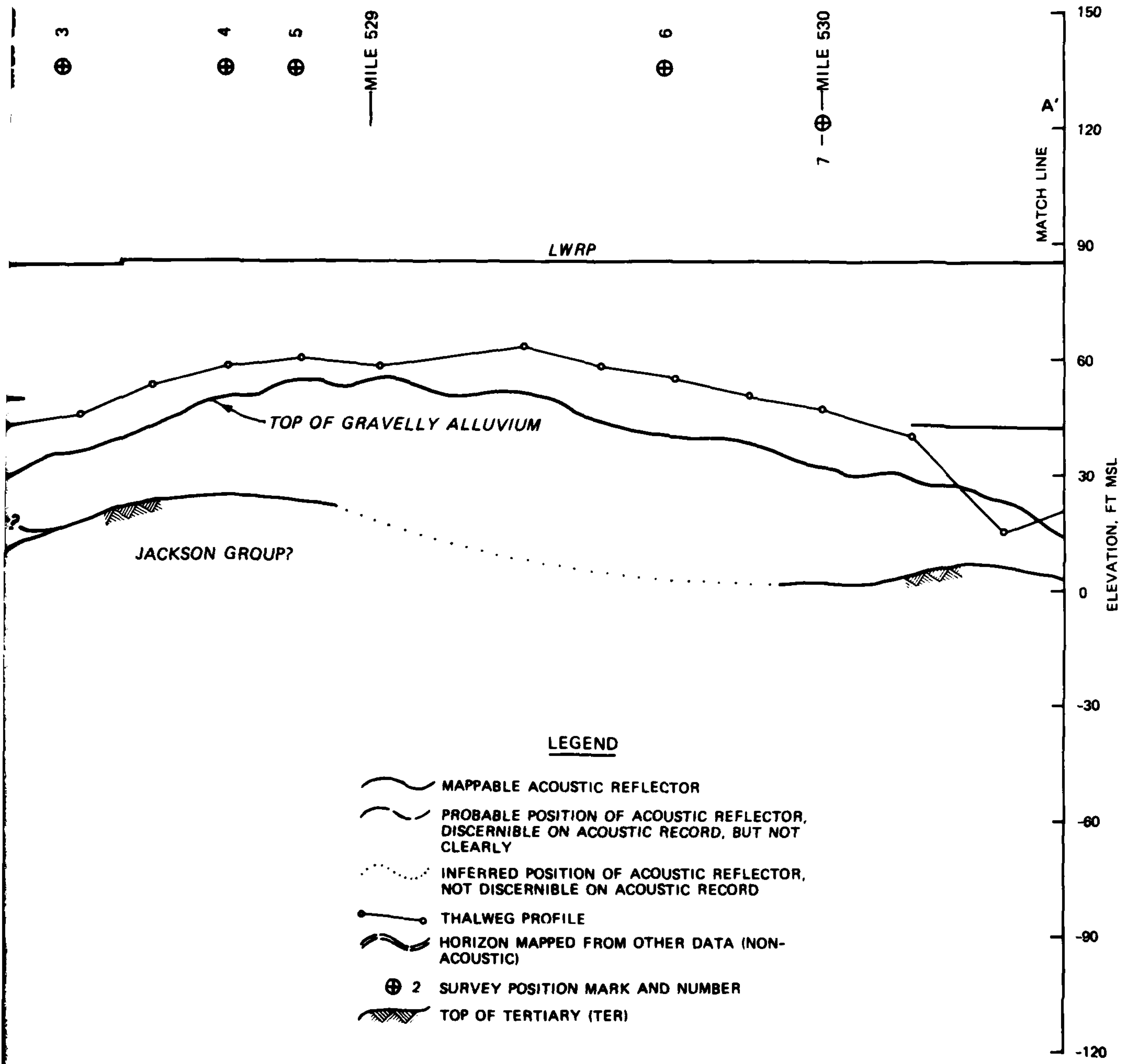


Figure 7. Profile AA', Mississippi River, 526.3 to 53



Profile AA', Mississippi River, 526.3 to 530.4 MAHP

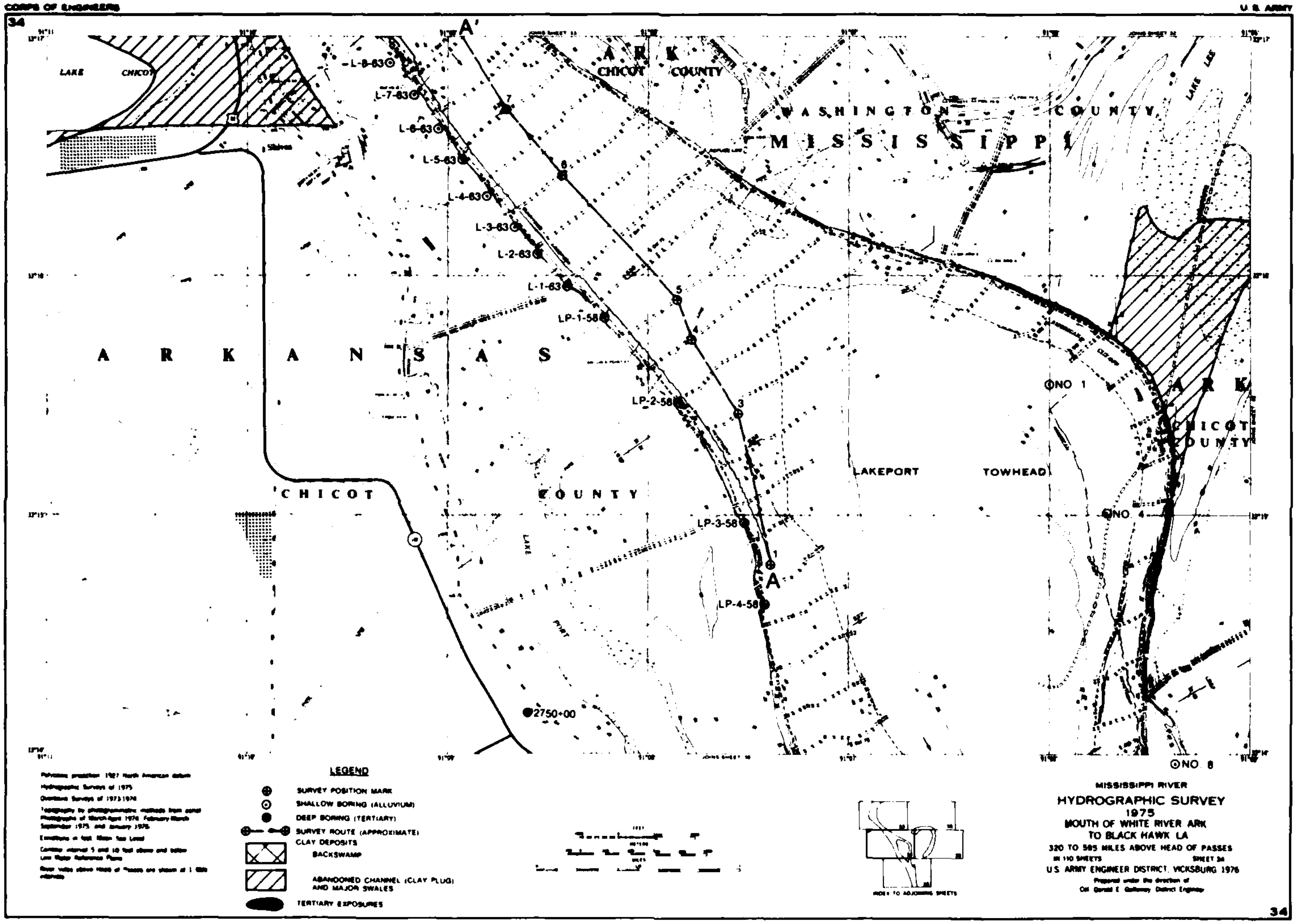


Figure 8. Geologic map, Mississippi River, 526.3 to 530.4 MAHP

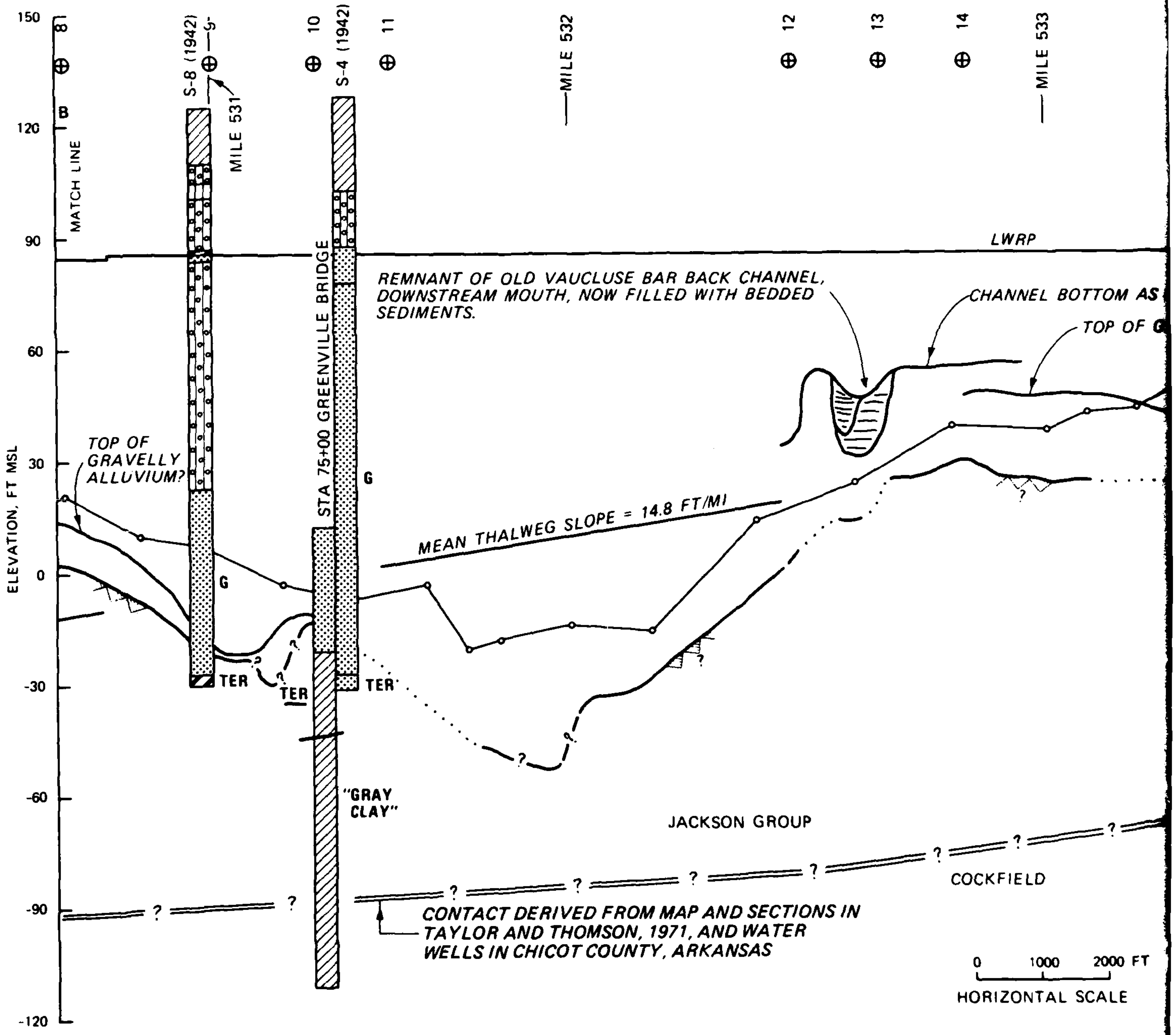
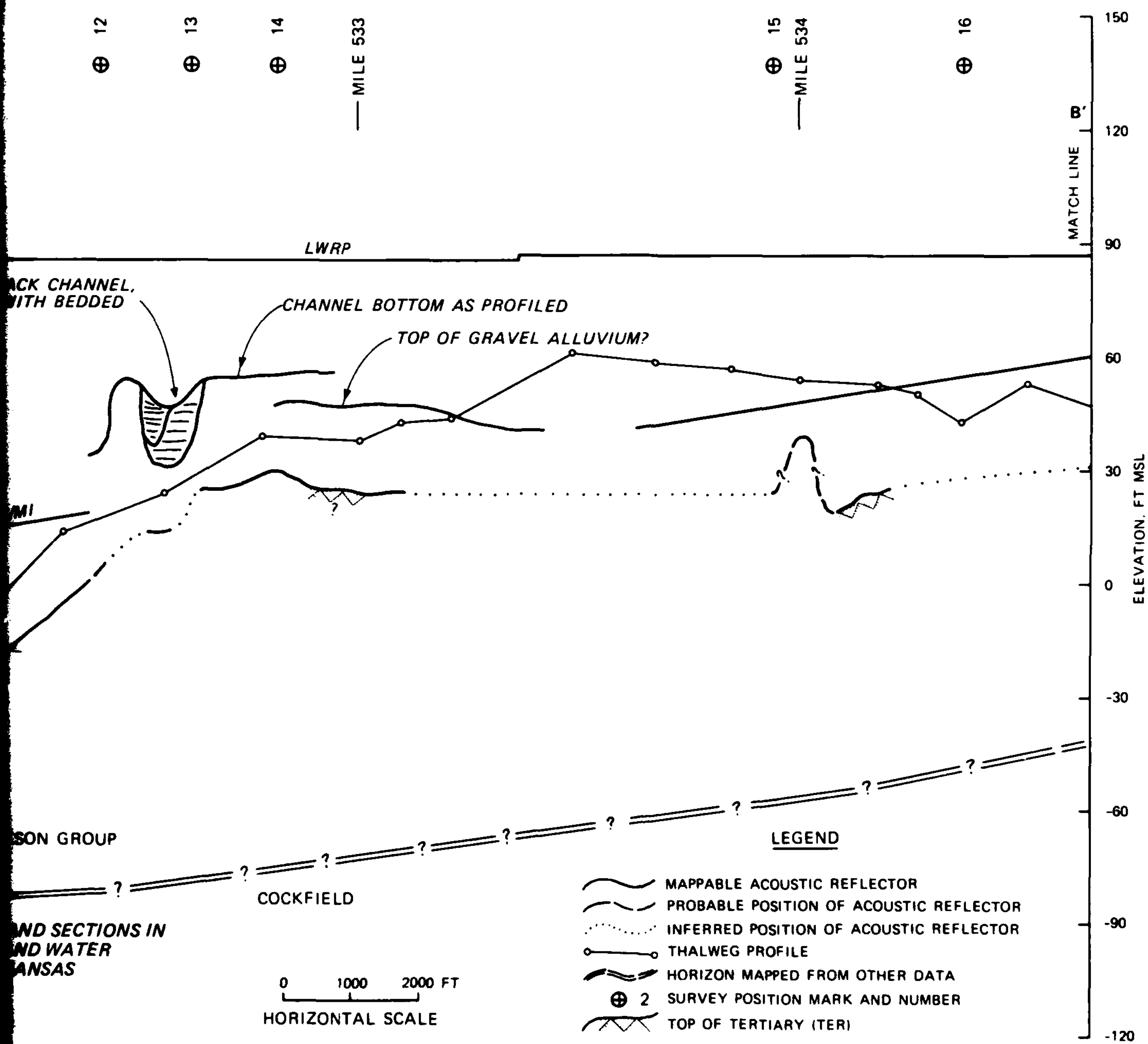


Figure 9. Profile BB', Mississippi River, 530.4 to



file BB', Mississippi River, 530.4 to 534.8 MAHP

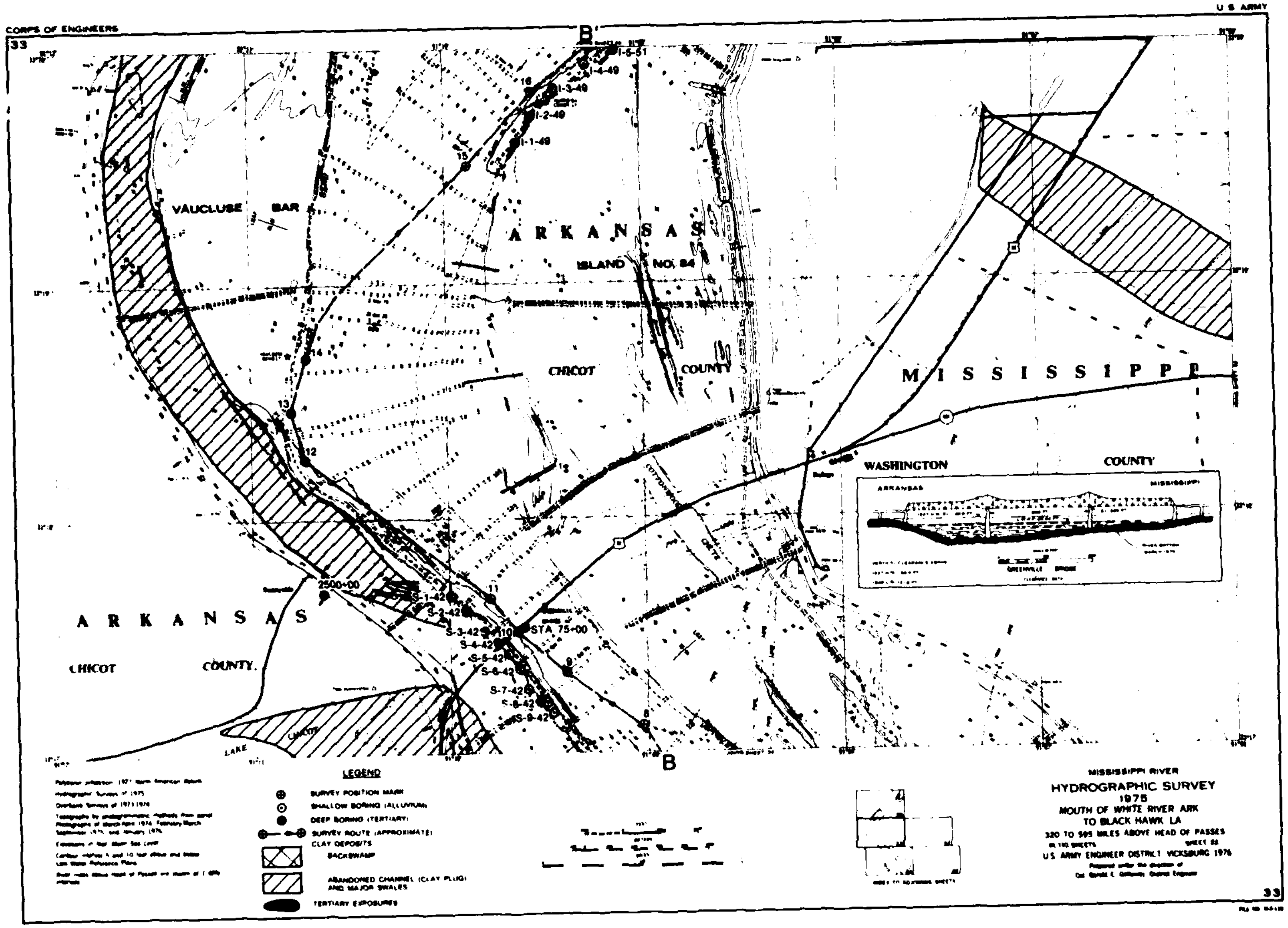


Figure 10. Geologic map, Mississippi River, 530.4 to 534.8 MAHP

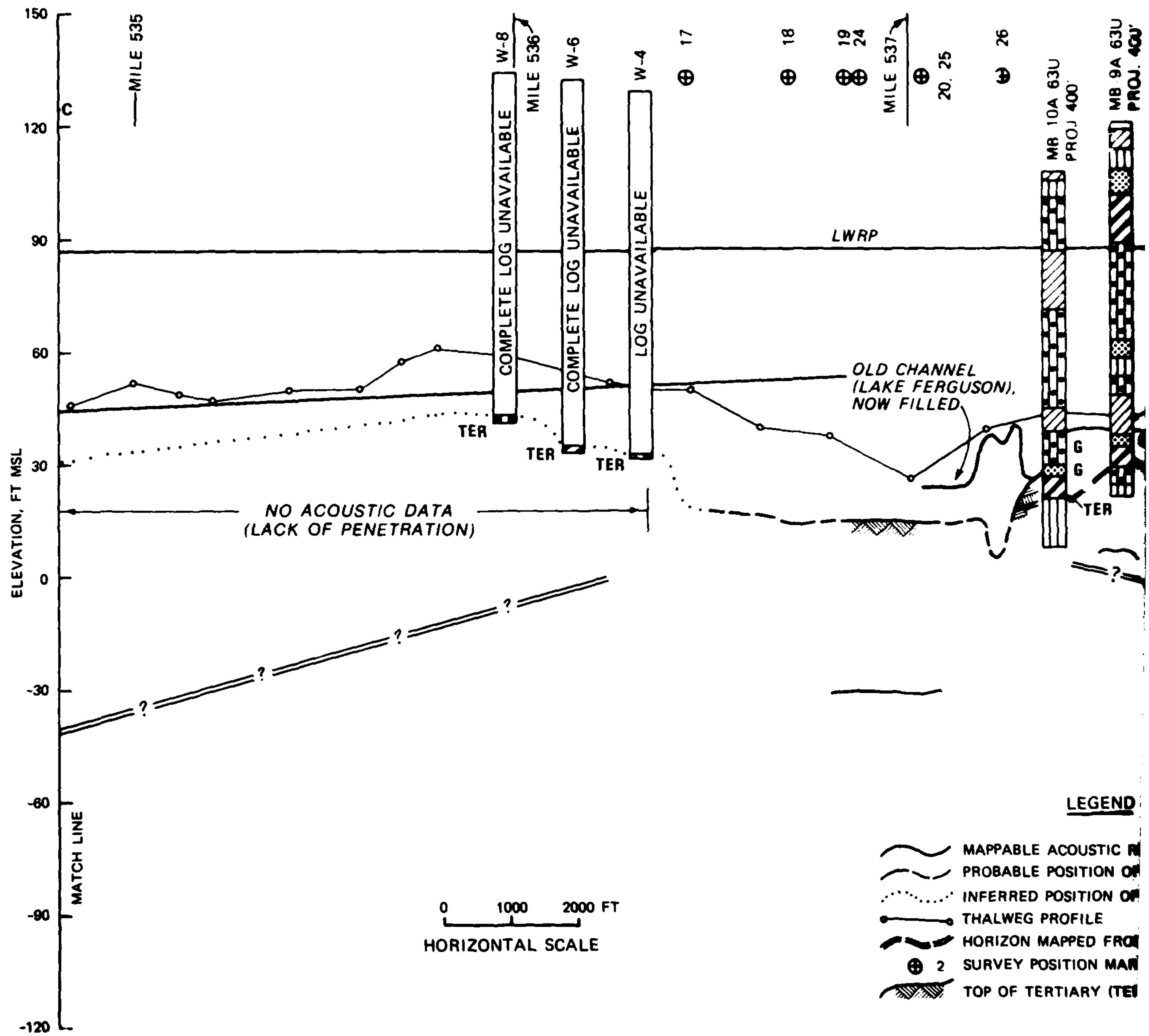
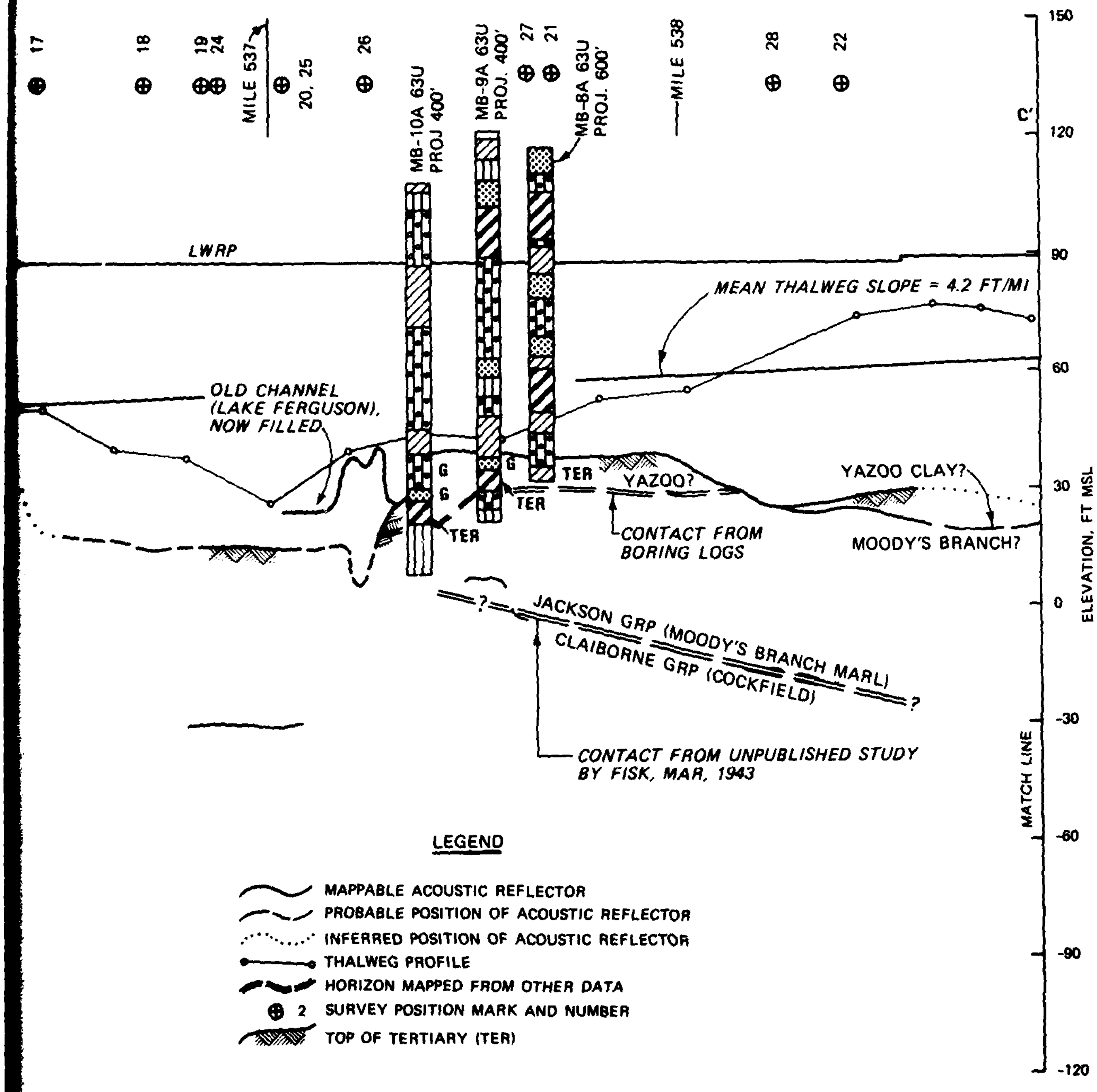


Figure 11. Profile CC', Mississippi River, 534.8 to 53



ile CC', Mississippi River, 534.8 to 539.0 MAHP

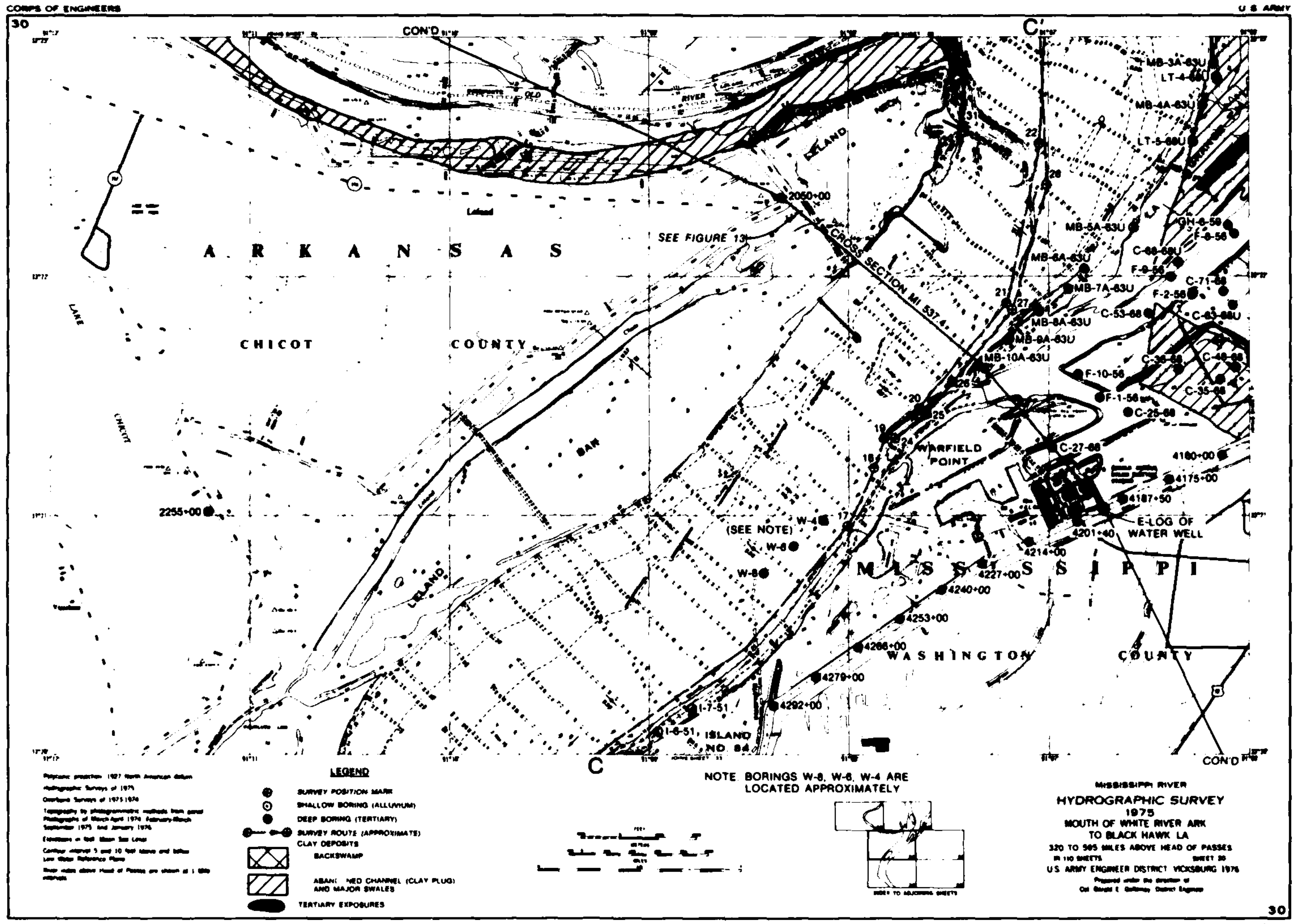


Figure 12. Geologic map, Mississippi River, 534.8 to 539.0 MAHP

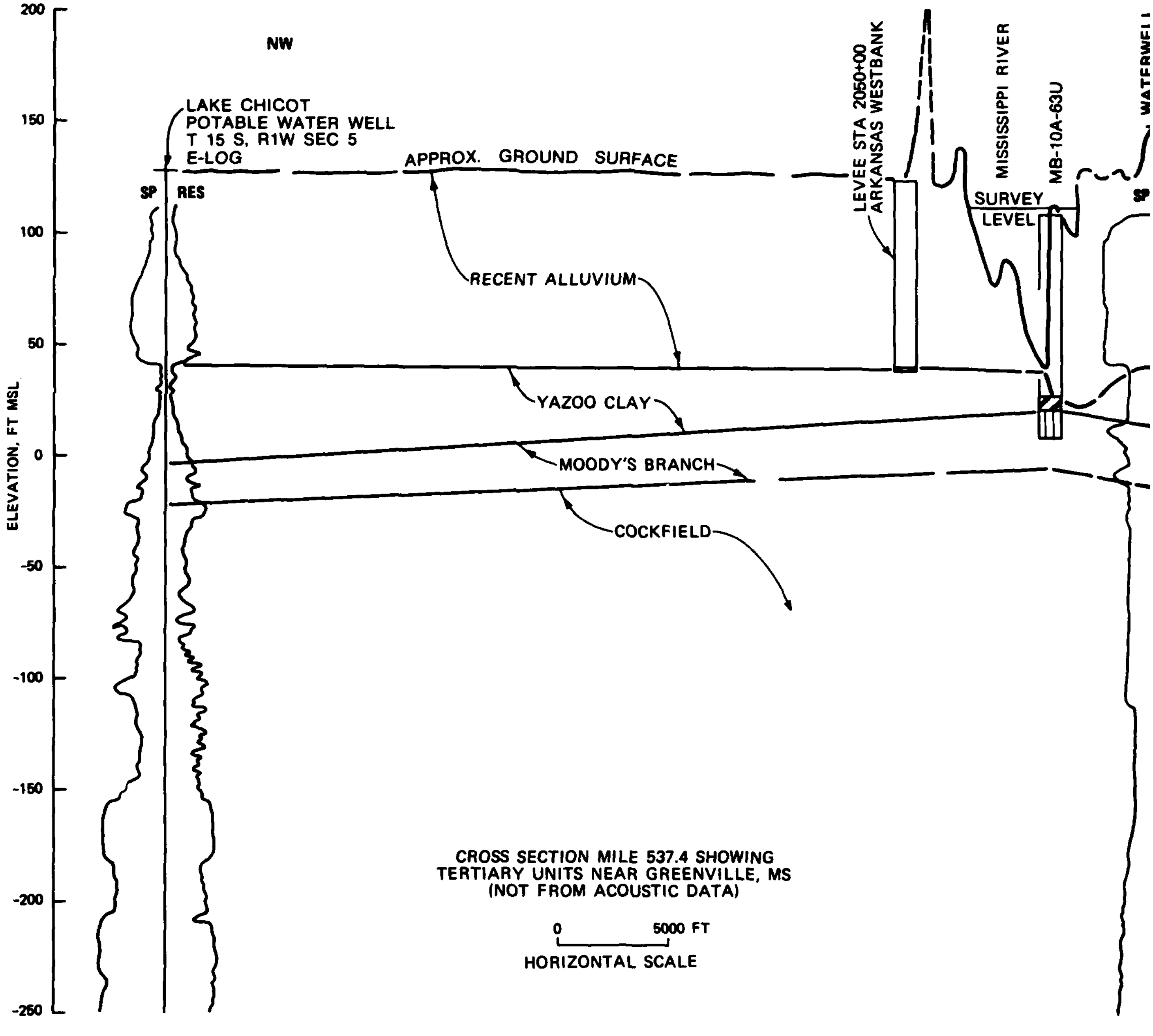
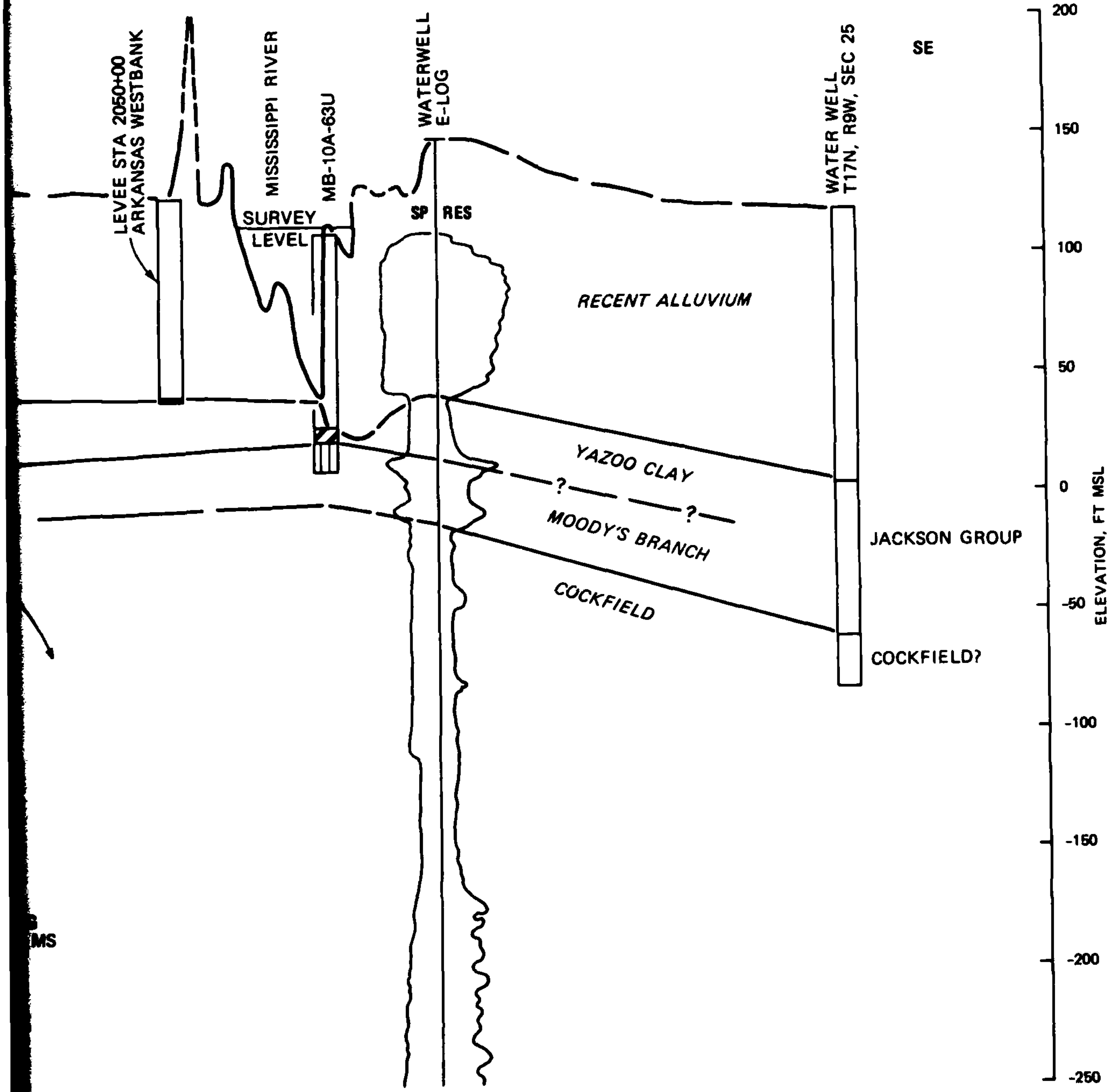


Figure 13. Geologic cross section near Greenville, Missis



section near Greenville, Mississippi, 537.4 MAHP

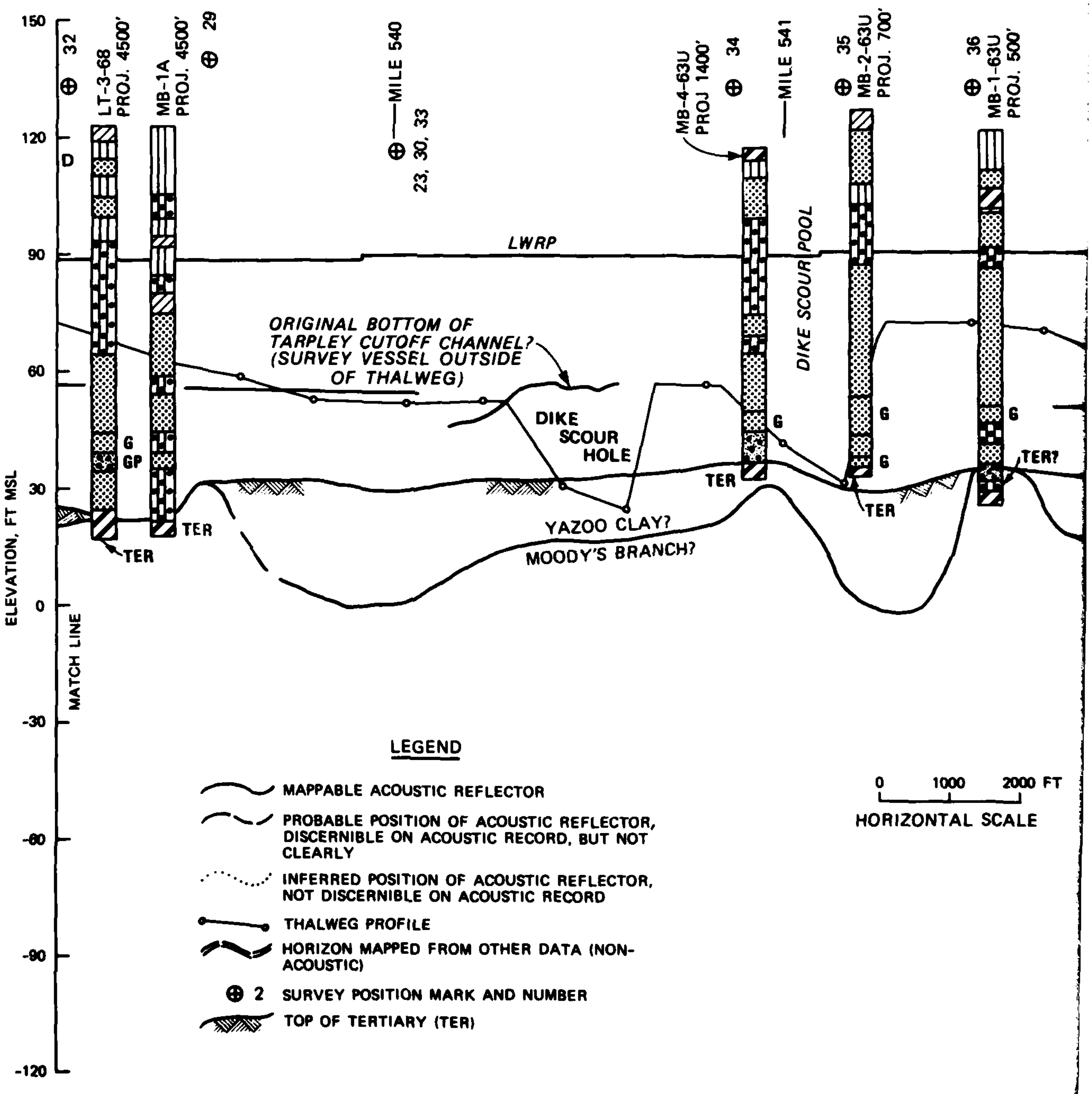
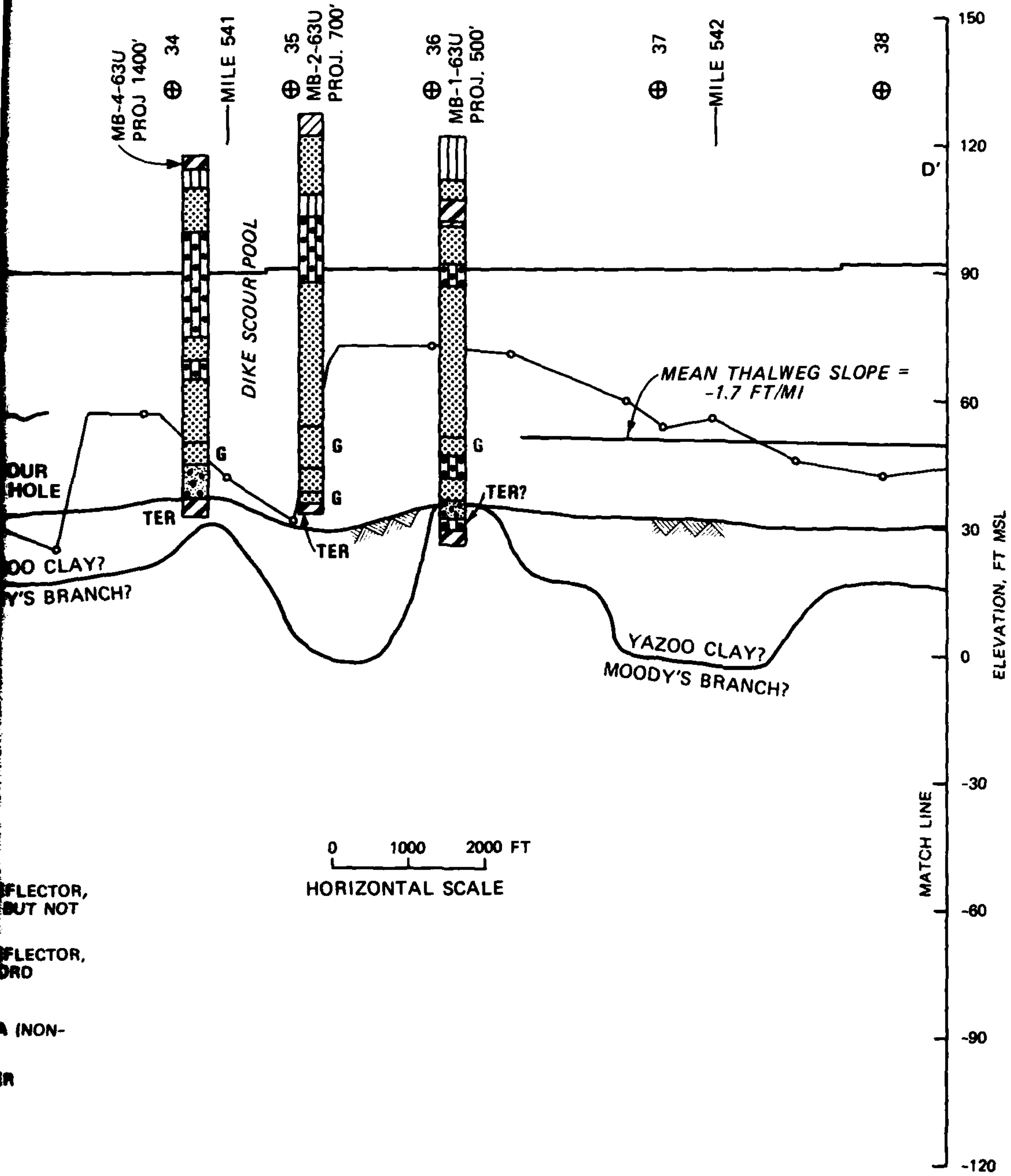


Figure 14. Profile DD', Mississippi River, 539.0 to 542.6



le DD', Mississippi River, 539.0 to 542.6 MAHP

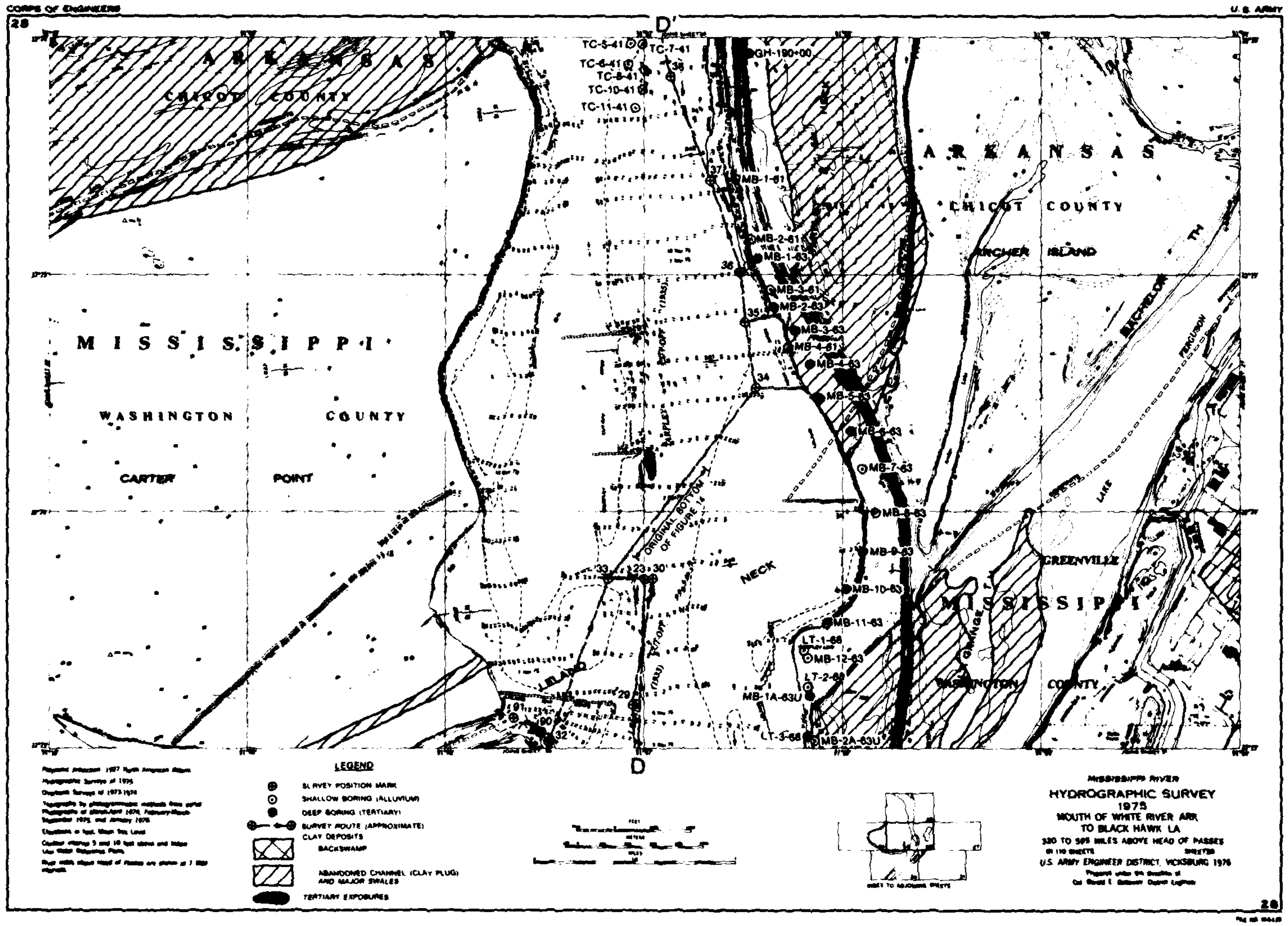


Figure 15. Geologic map, Mississippi River, 539.0 to 542.6 MAHP

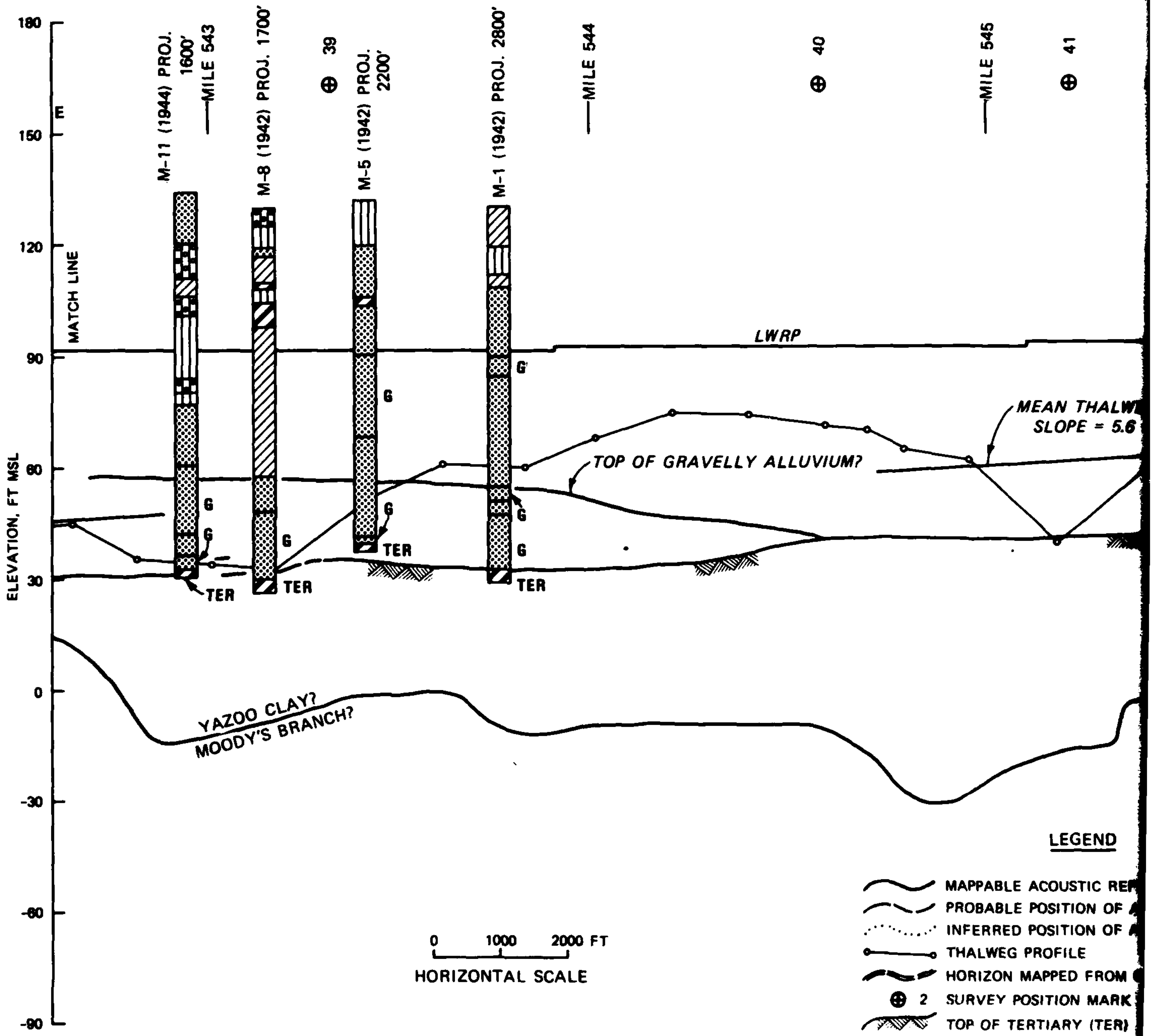
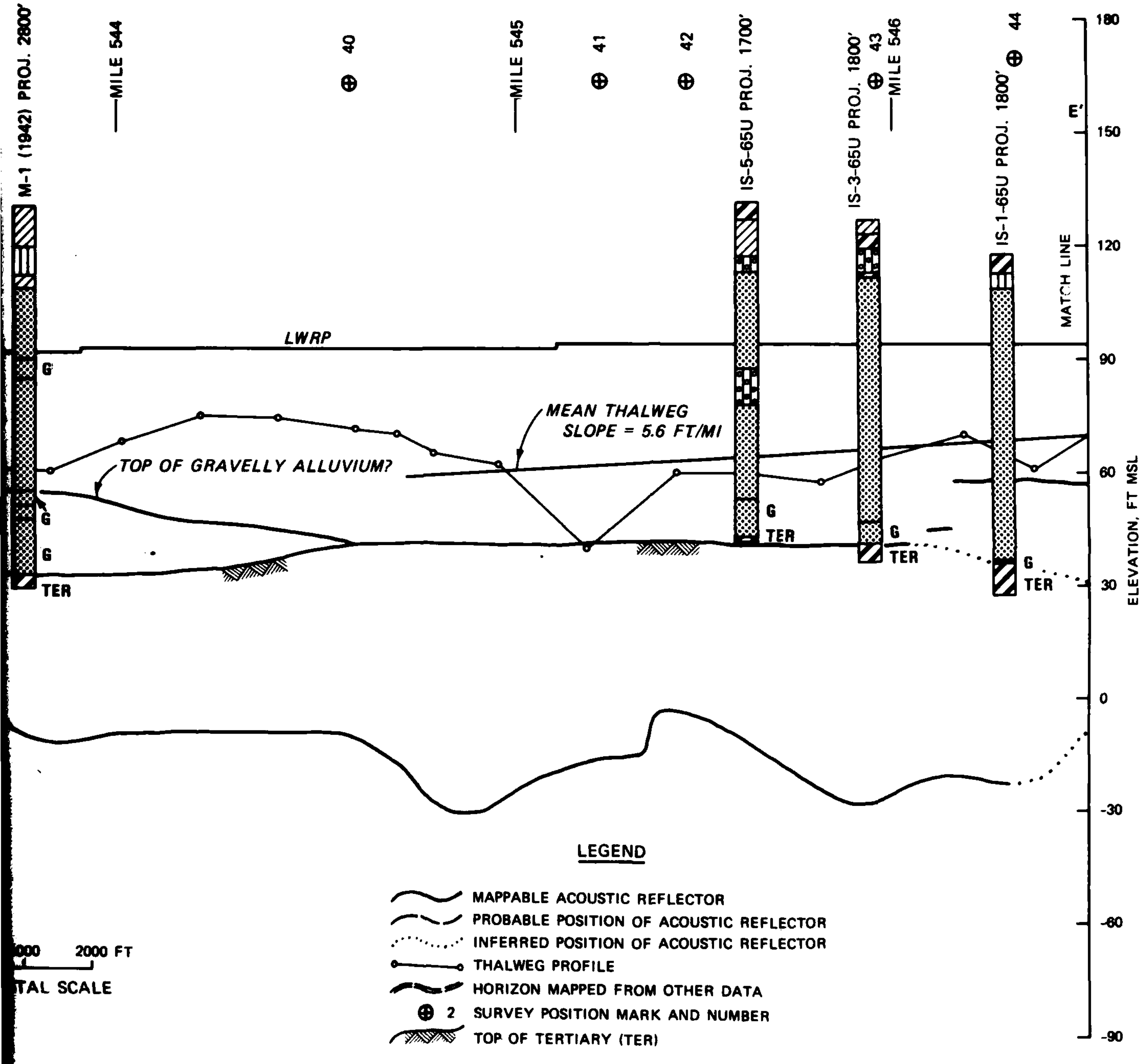


Figure 16. Profile EE', Mississippi River, 542.6 to 546.5 M



e 16. Profile EE', Mississippi River, 542.6 to 546.5 MAHP

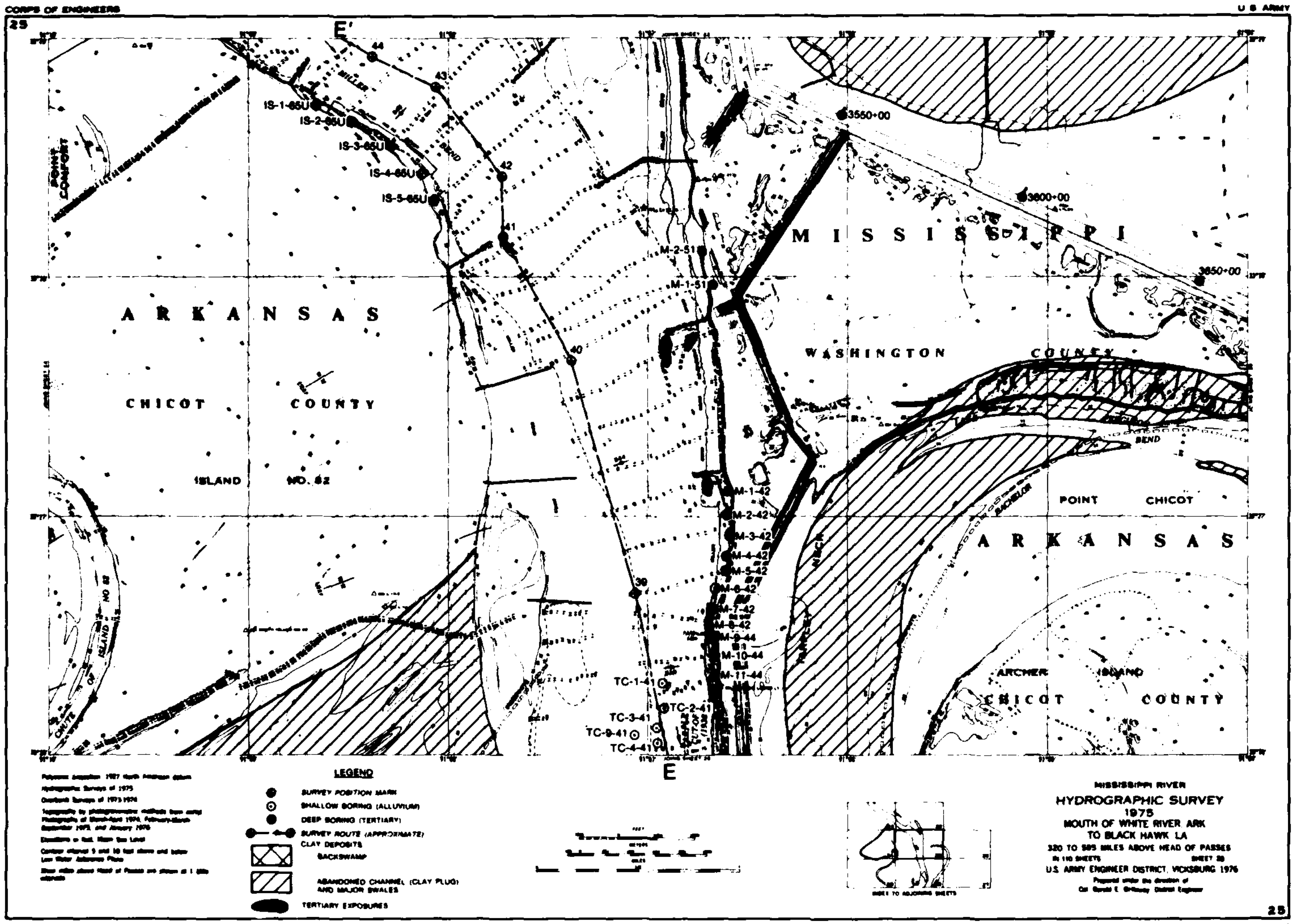


Figure 17. Geologic map, Mississippi River, 542.6 to 546.5 MAHP

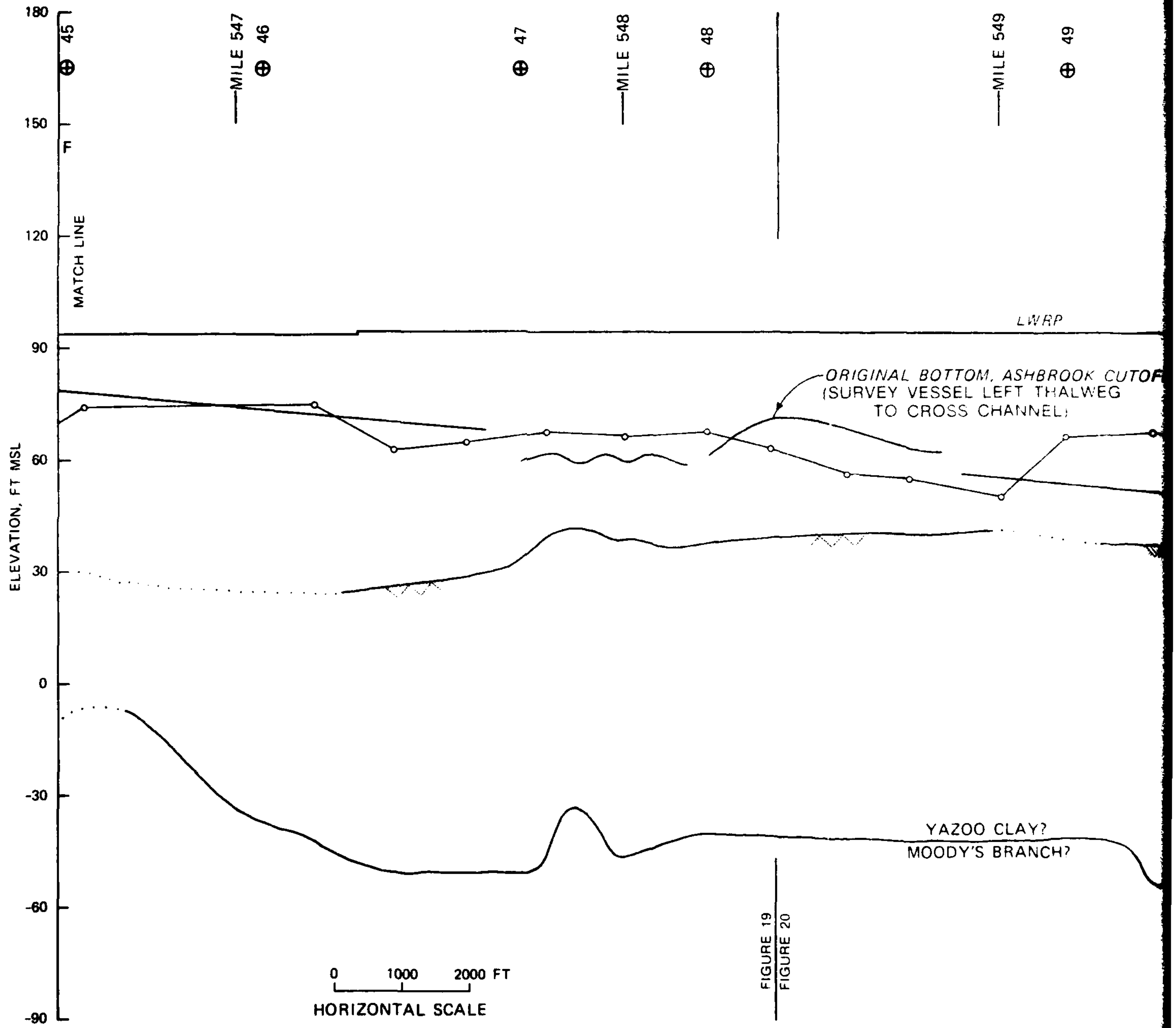
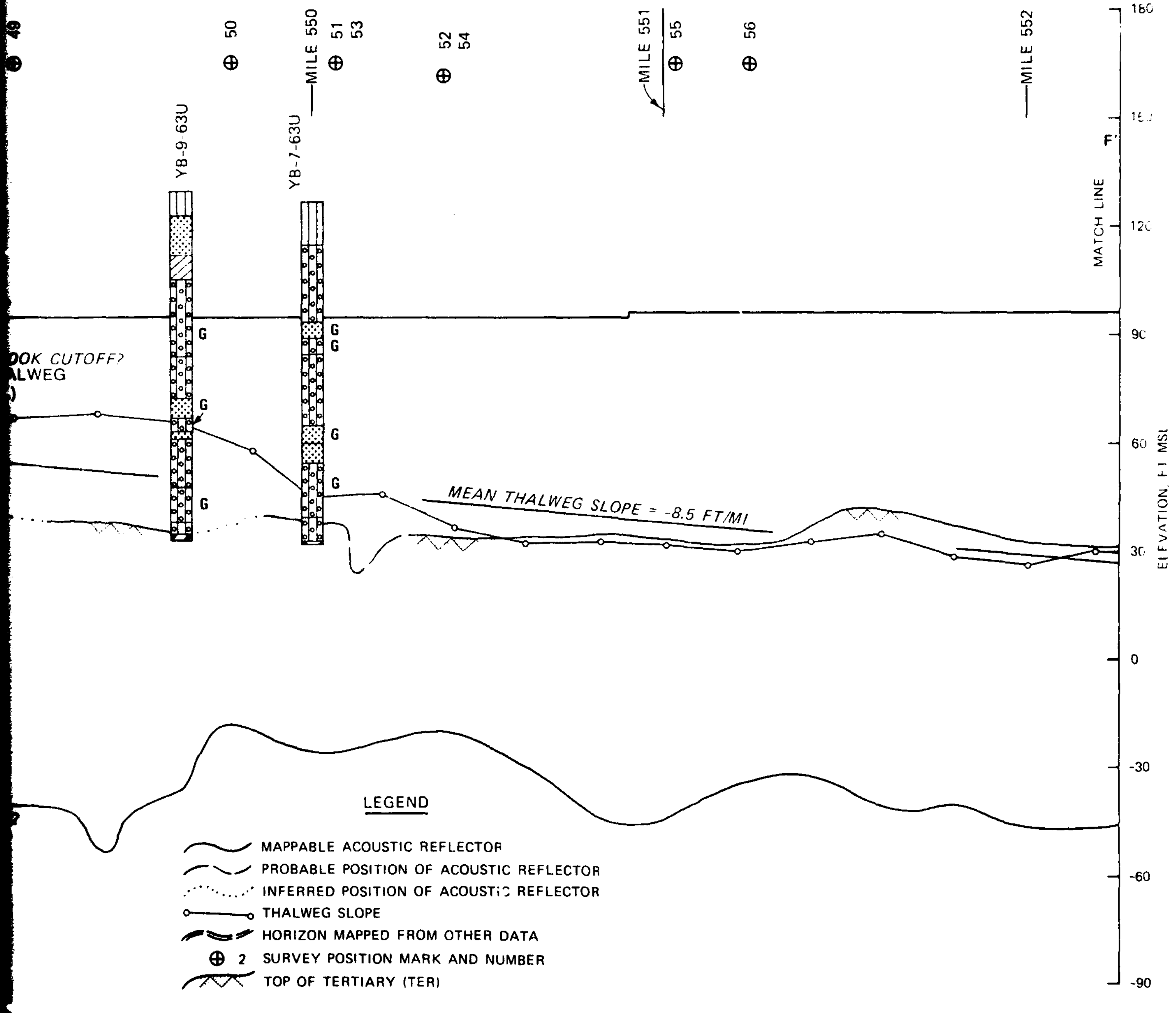


Figure 18. Profile FF', Mississi



Mississippi River, 546.5 to 552.2 MAHP

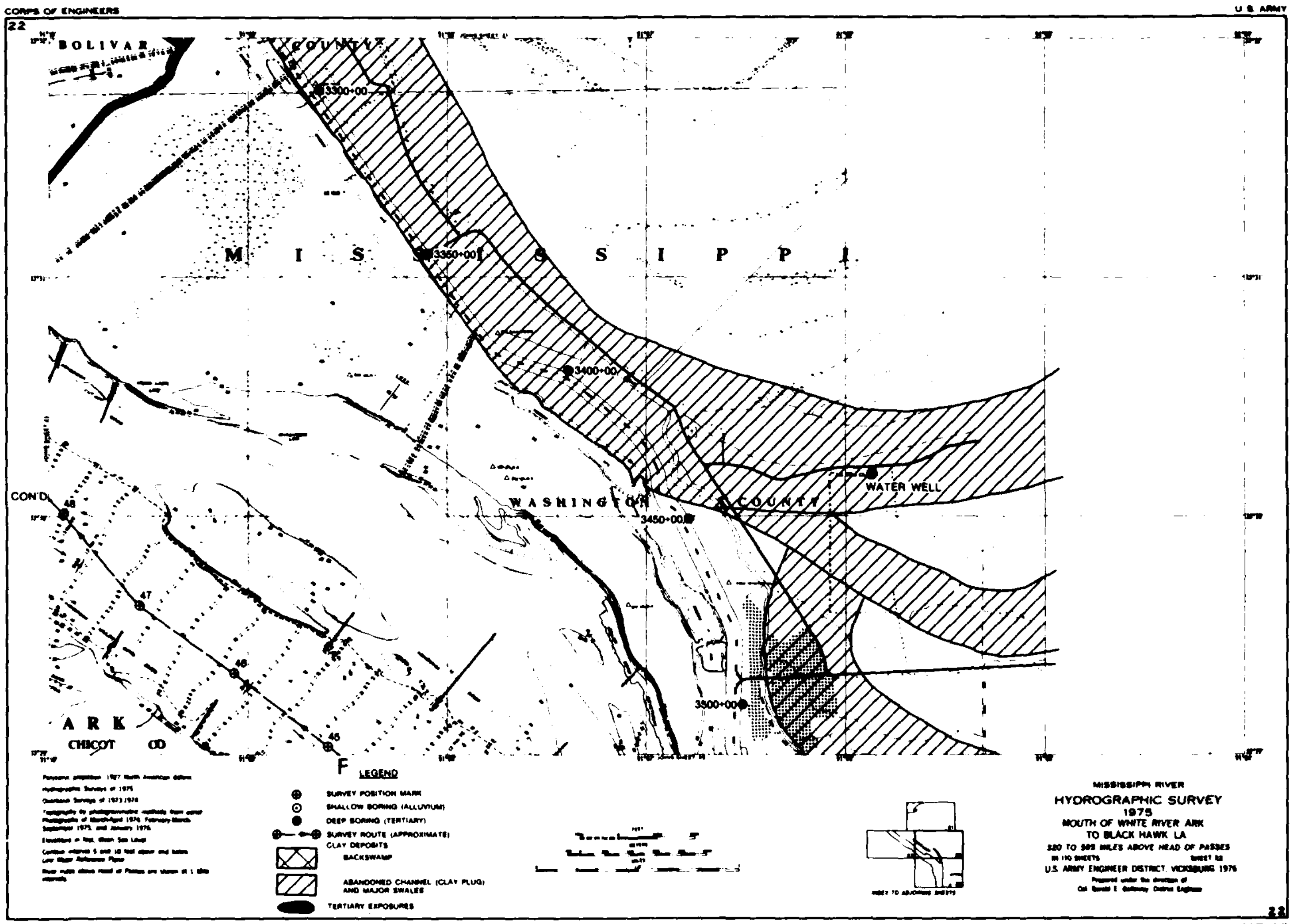


Figure 19. Geologic map, Mississippi River, 546.5 to 548.2 MAHP

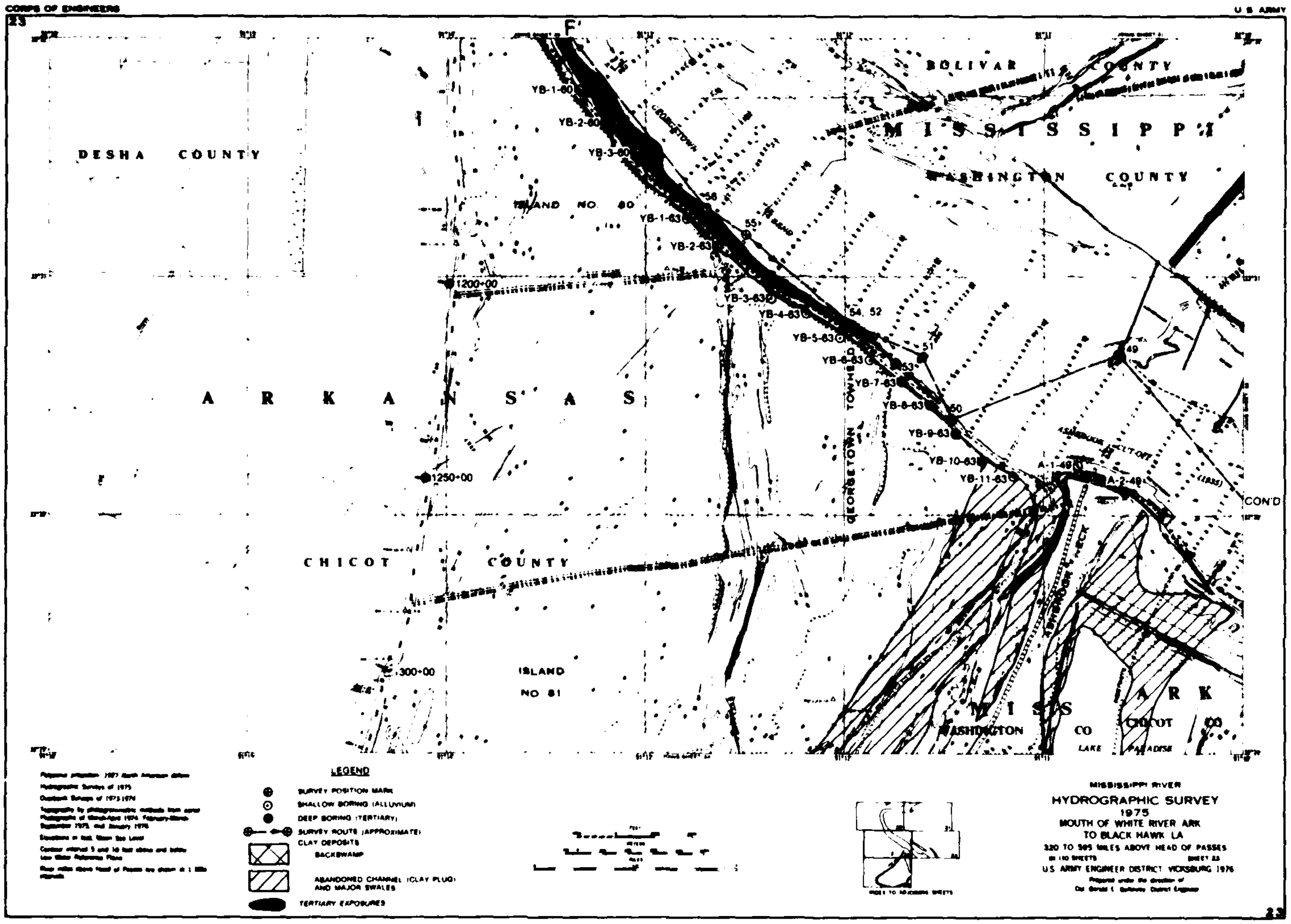
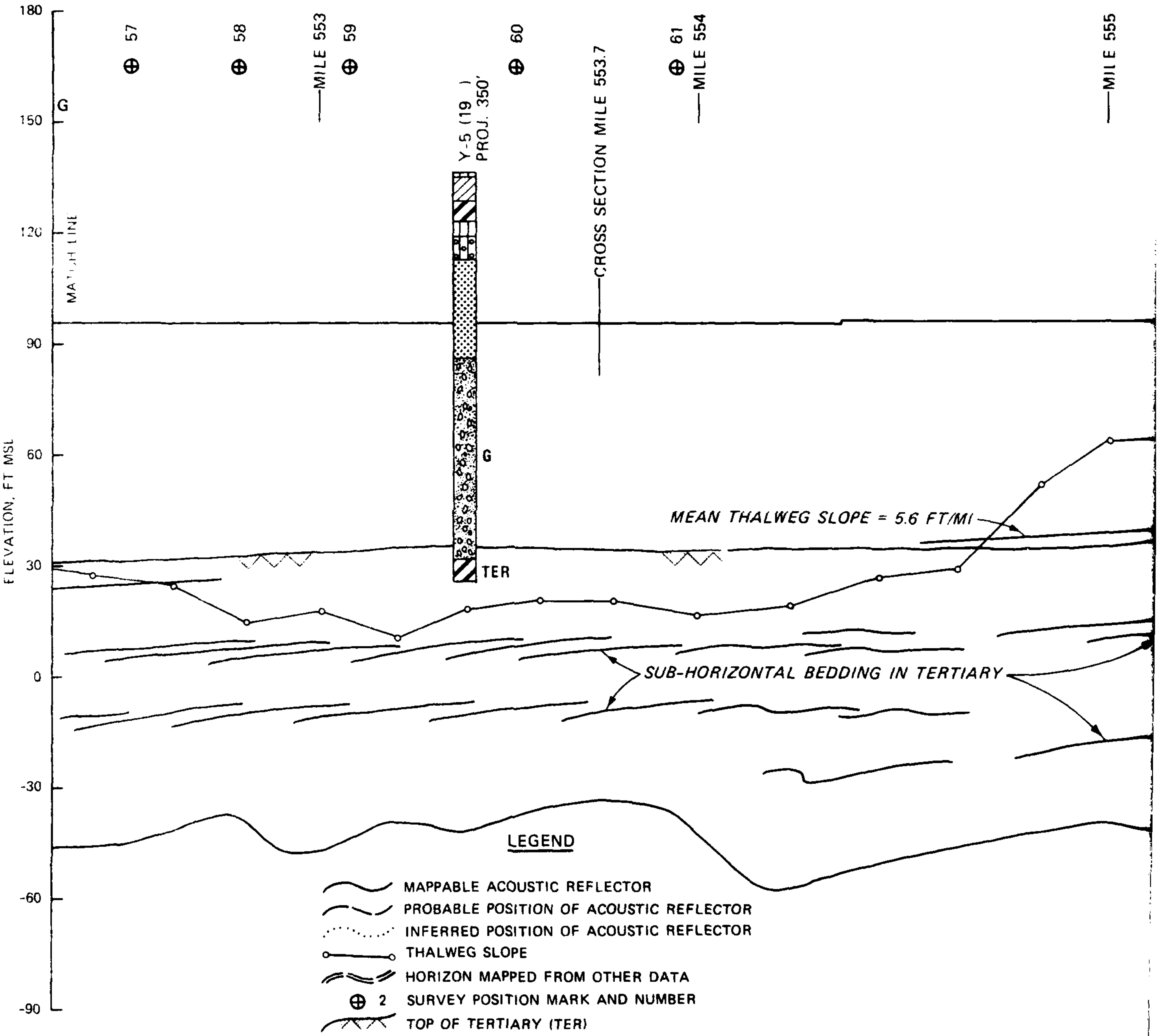


Figure 20. Geologic map, Mississippi River, 548.2 to 552.2 MAHP



ELEVATION, FT MSL
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0
-30
-60
-90
57
58
59
60
61
MILE 553
MILE 554
MILE 555
G
MATCH LINE
Y-5 (19)
PROJ. 350'
CROSS SECTION MILE 553.7
G
TER
MEAN THALWEG SLOPE = 5.6 FT/MI
SUB-HORIZONTAL BEDDING IN TERTIARY
LEGEND
MAPPABLE ACOUSTIC REFLECTOR
PROBABLE POSITION OF ACOUSTIC REFLECTOR
INFERRED POSITION OF ACOUSTIC REFLECTOR
THALWEG SLOPE
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2 SURVEY POSITION MARK AND NUMBER
TOP OF TERTIARY (TER)

Figu

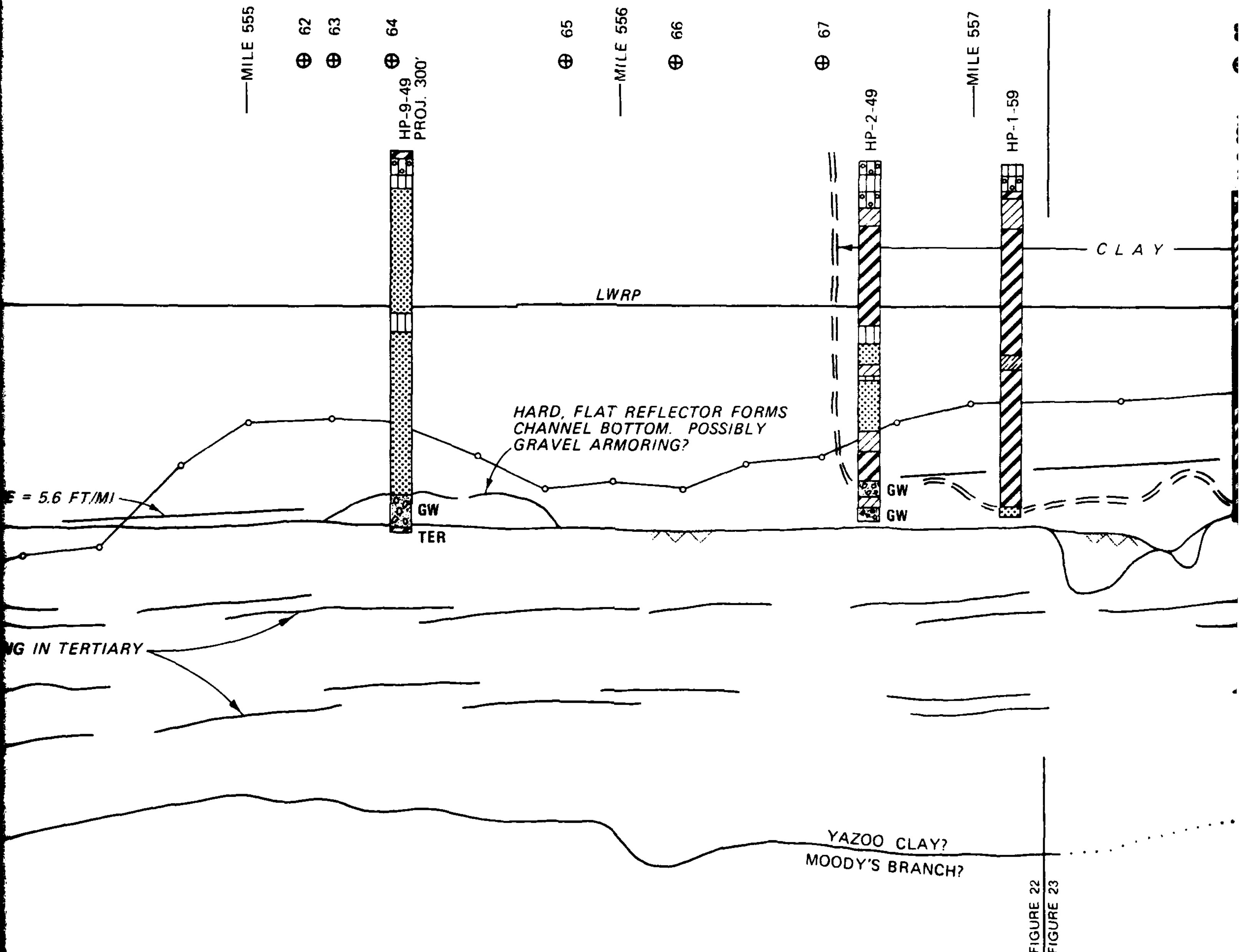
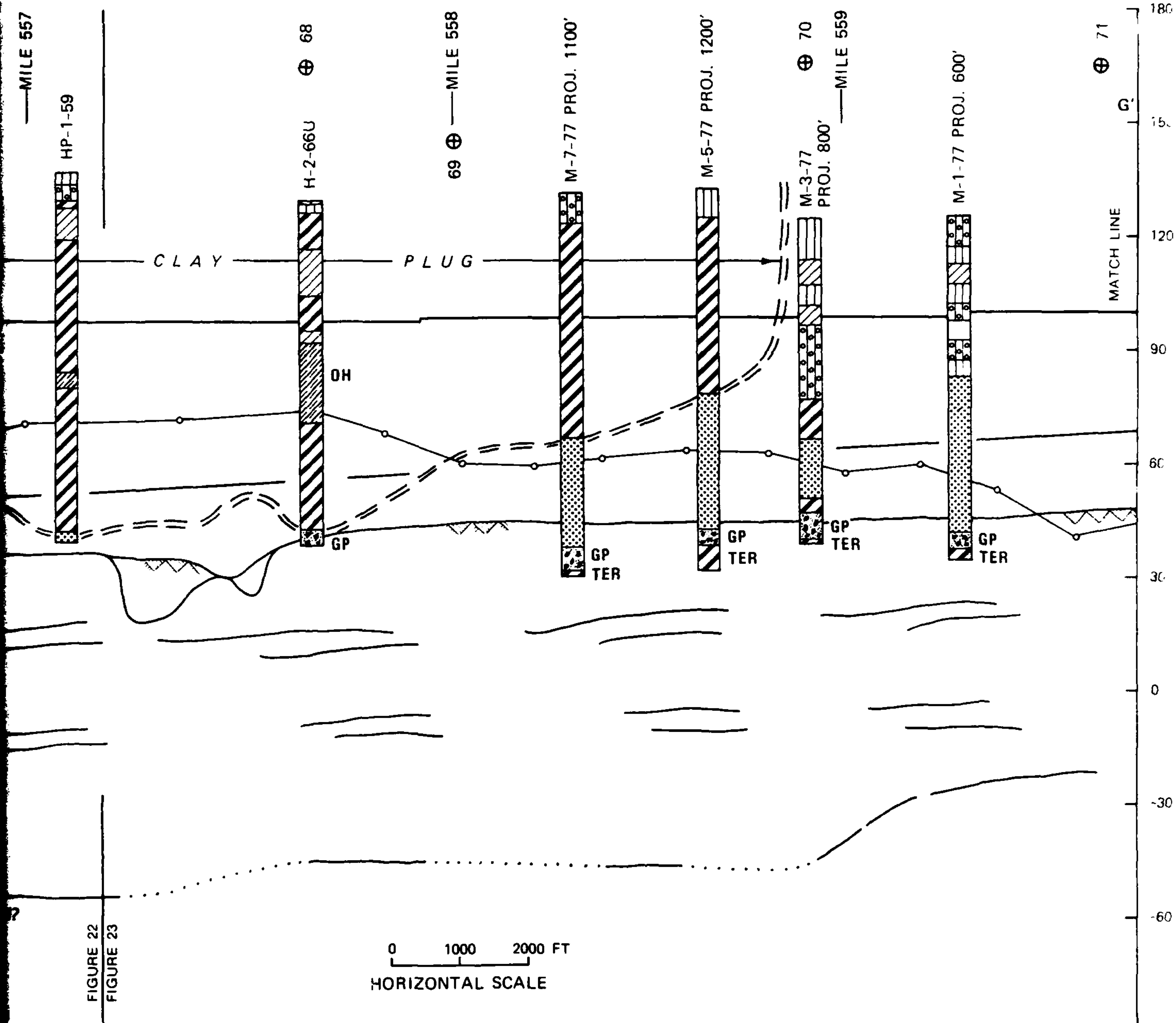


Figure 21. Profile GG', Mississippi River, 552.2 to 559.8 MAHP


MILE 557
HP-1-59
H-2-66U
68
69
MILE 558
M-7-77 PROJ. 1100'
M-5-77 PROJ. 1200'
70
M-3-77
PROJ. 800'
MILE 559
M-1-77 PROJ. 600'
71
G'
MATCH LINE
CLAY
PLUG
OH
GP
GP
TER
GP
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TER
GP
TER
180
150
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-30
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-90
ELEVATION, FT MSL
FIGURE 22
FIGURE 23
0
1000
2000 FT
HORIZONTAL SCALE

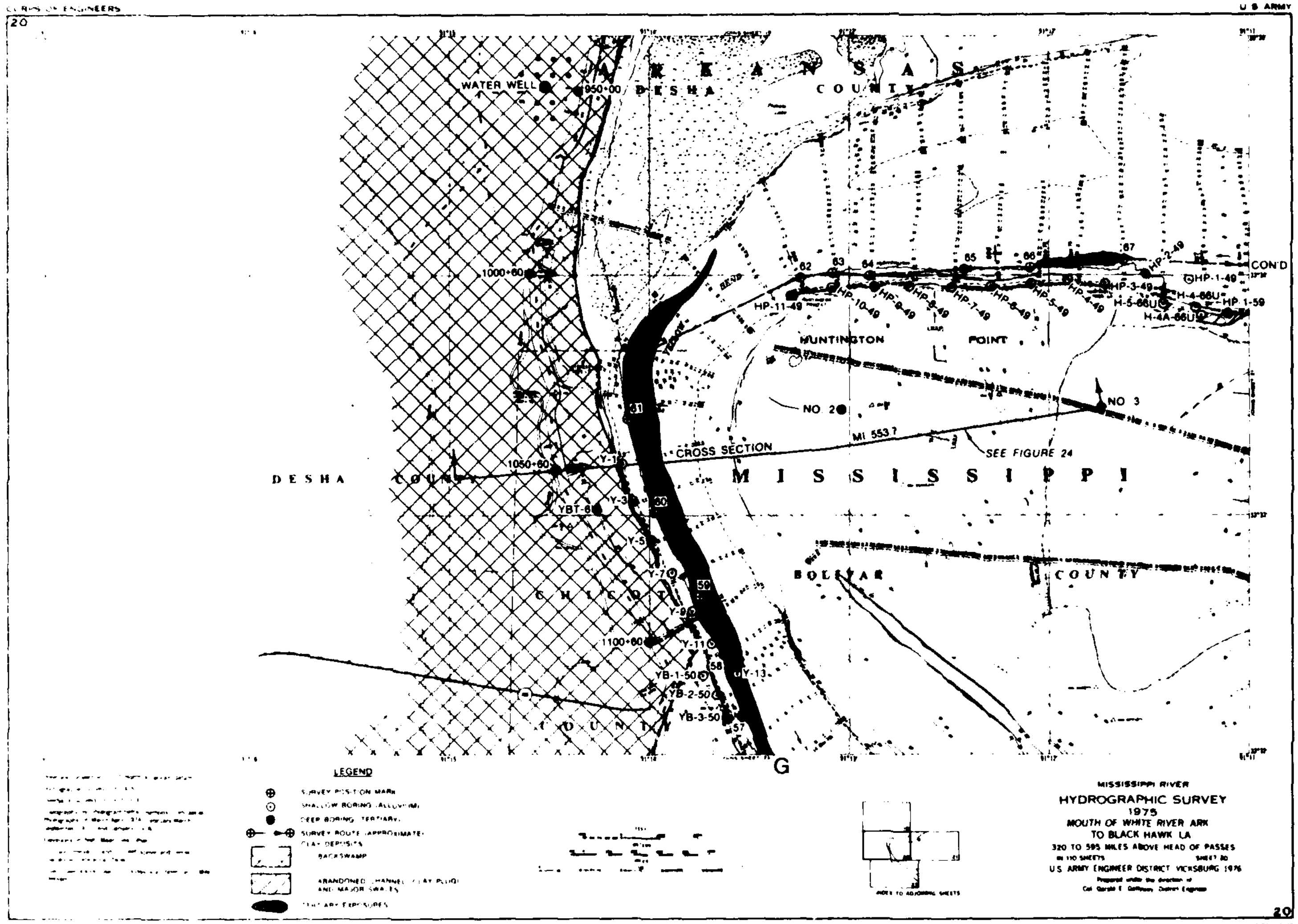


Figure 22. Geologic map, Mississippi River, 552.2 to 557.2 MAHP

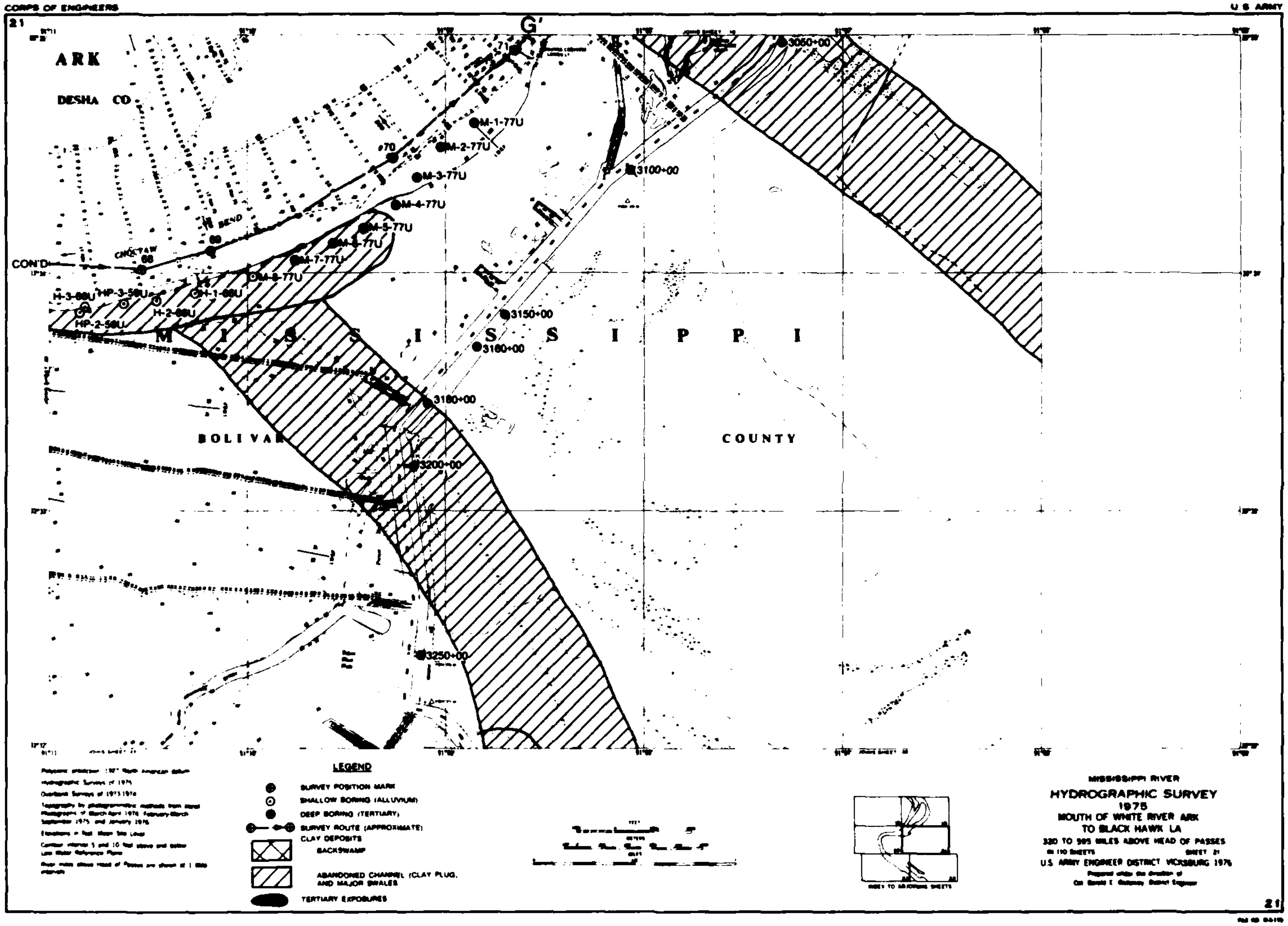


Figure 23. Geologic map, Mississippi River, 557.2 to 559.8 MAHP

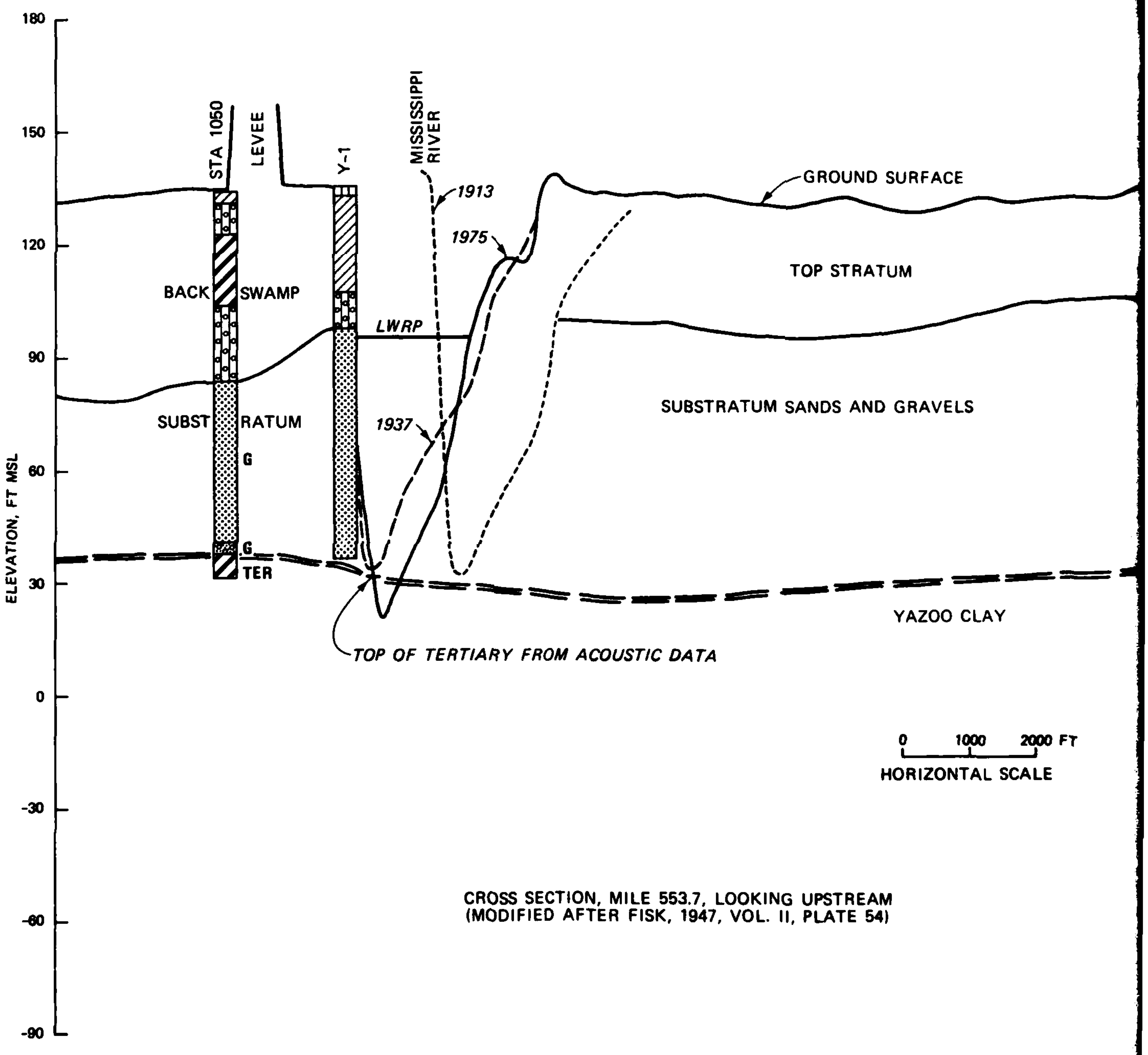
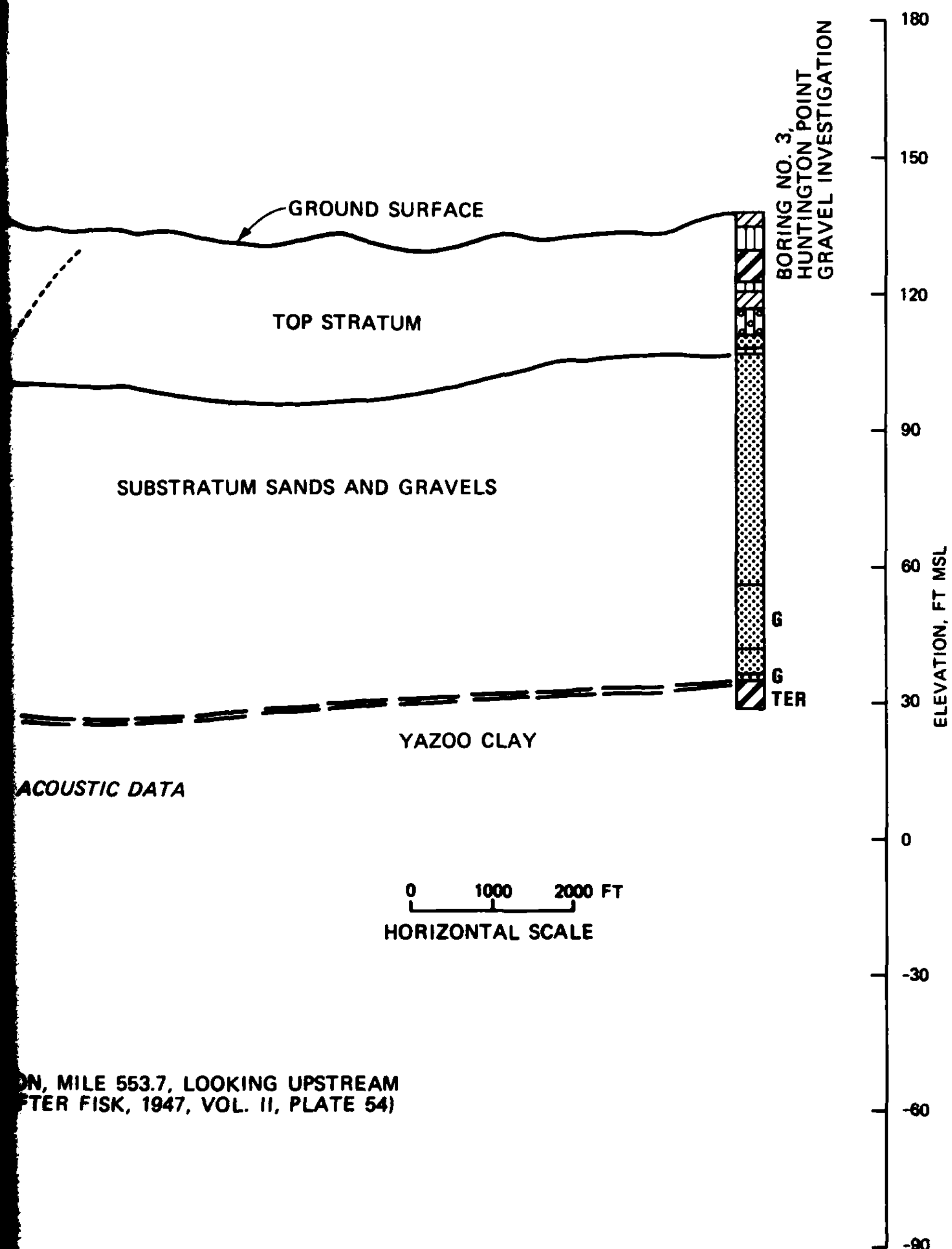


Figure 24. Geologic cross section near Yellow Bend, Mississippi River, 553.7 MA



ON, MILE 553.7, LOOKING UPSTREAM
FTER FISK, 1947, VOL. II, PLATE 54)

n near Yellow Bend, Mississippi River, 553.7 MAHP

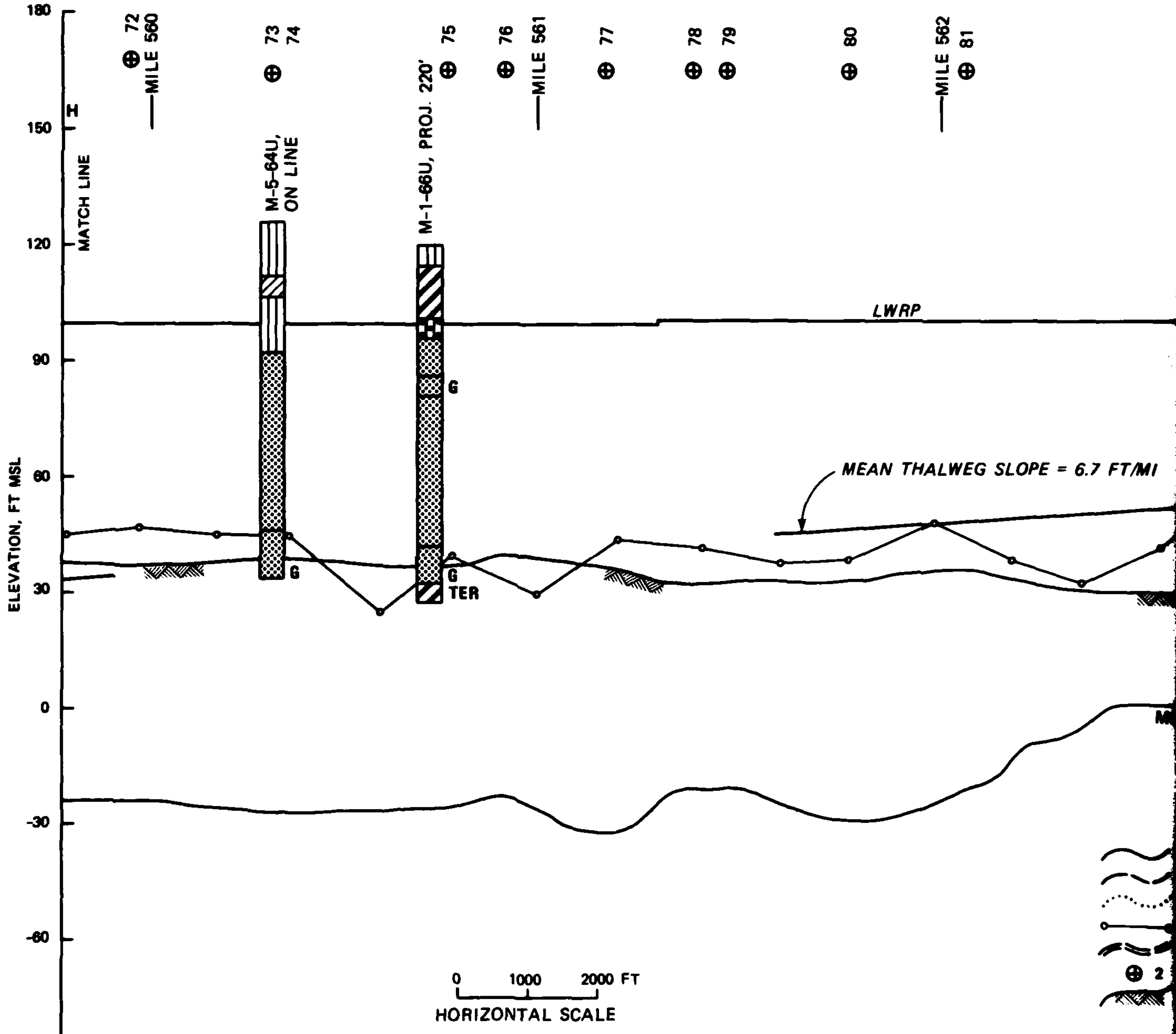
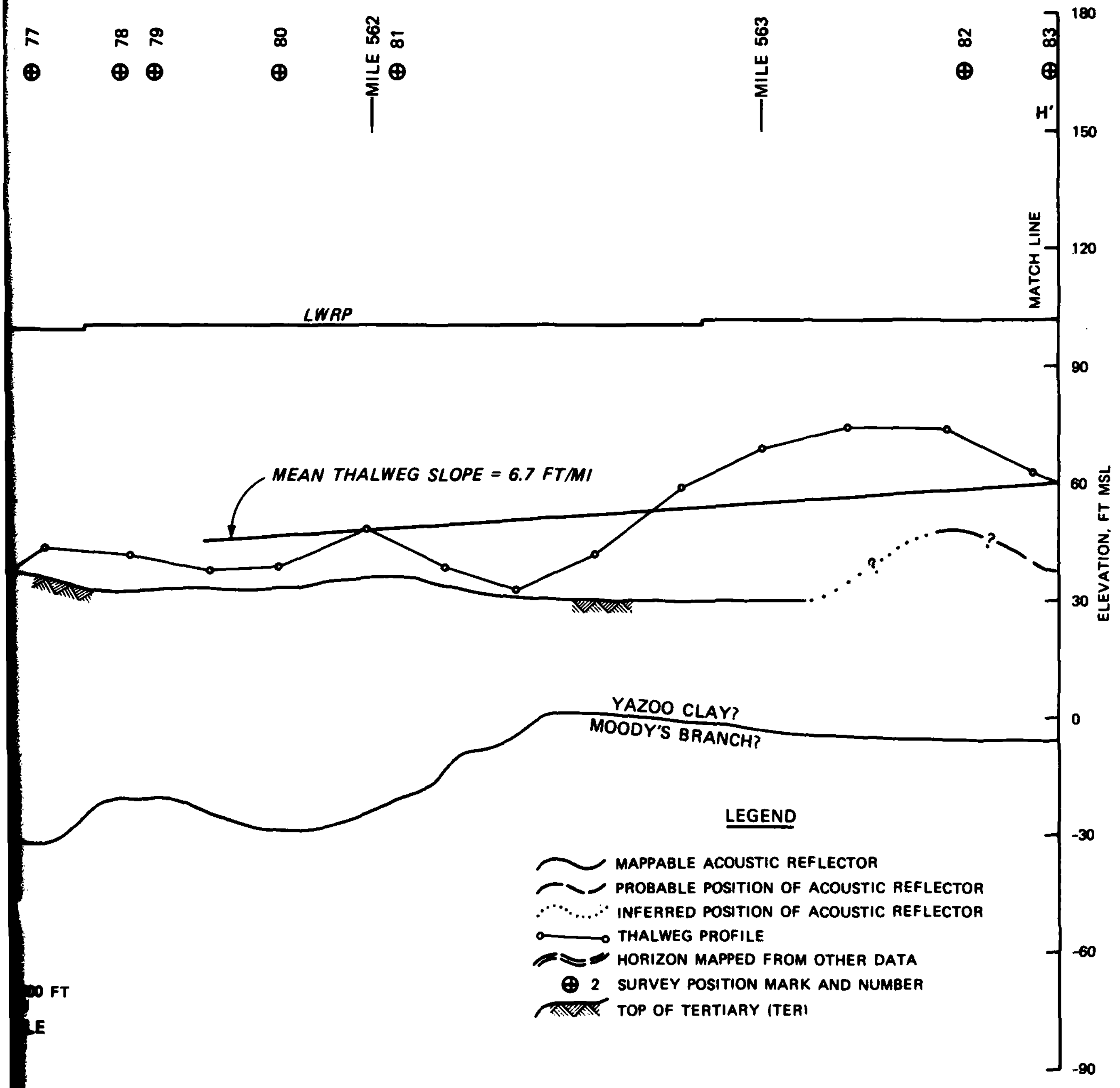


Figure 25. Profile HH', Mississippi River, 559.8 to 563.7



Profile HH', Mississippi River, 559.8 to 563.7 MAHP

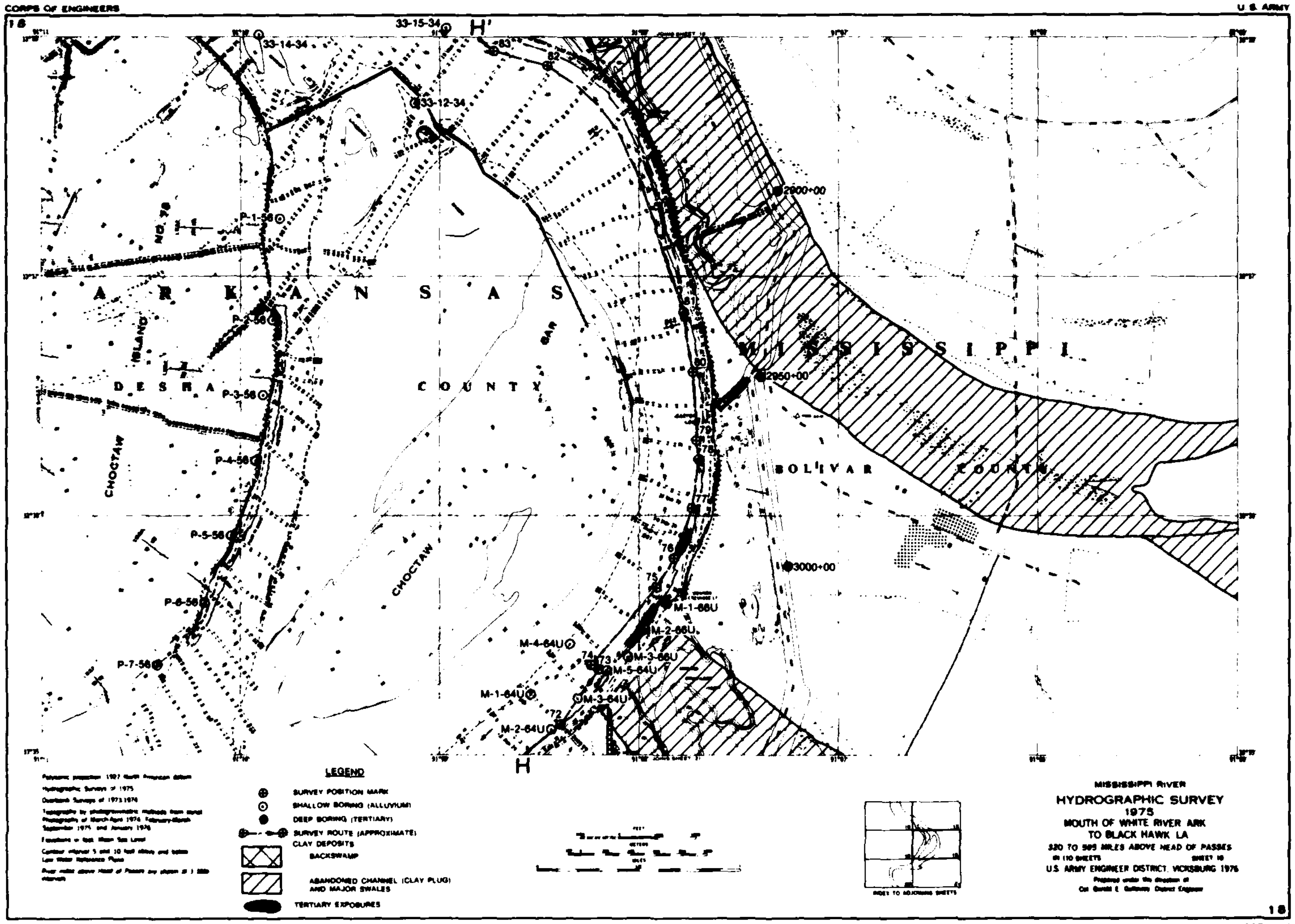


Figure 26. Geologic map, Mississippi River, 559.8 to 563.7 MAHP

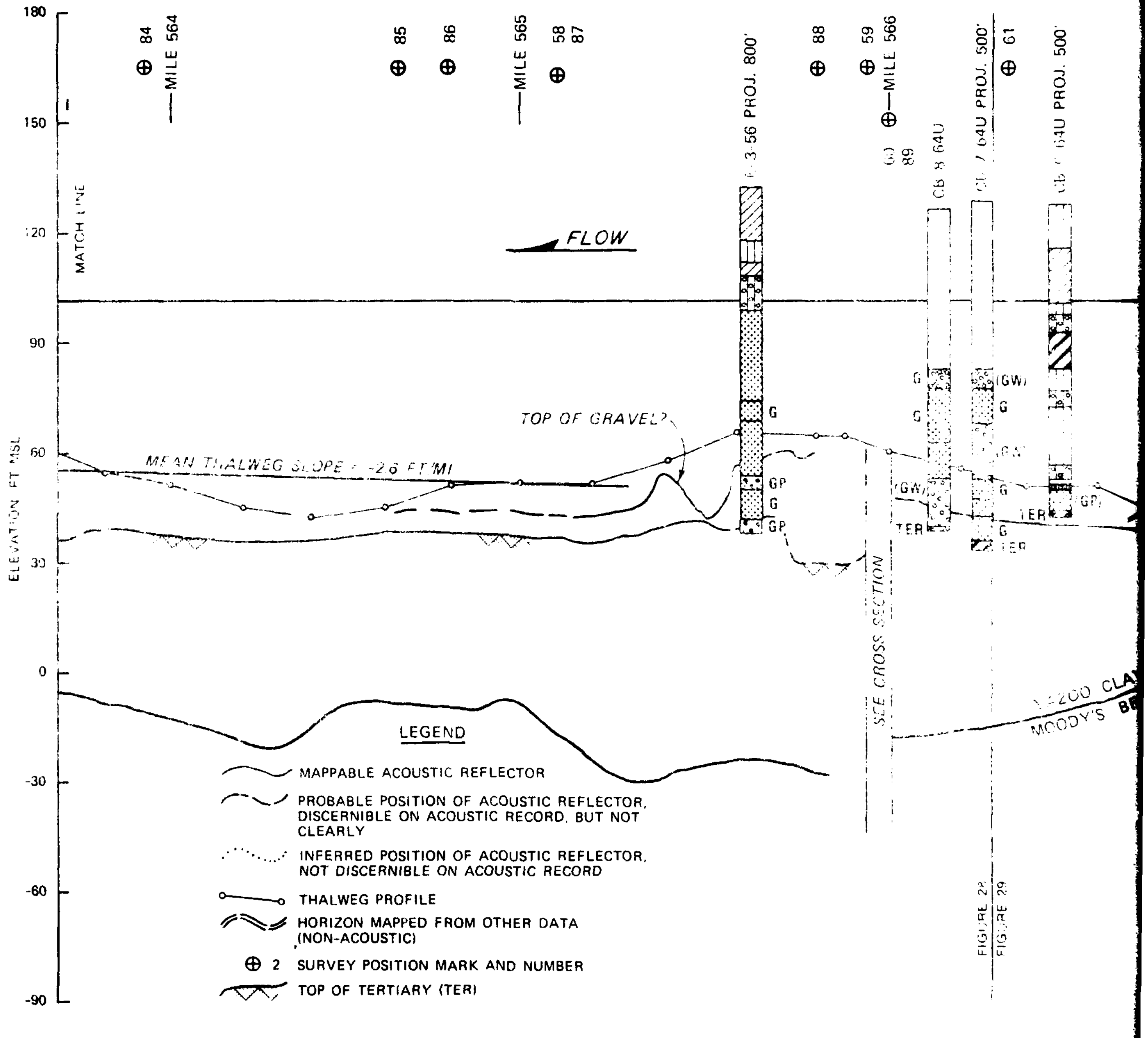
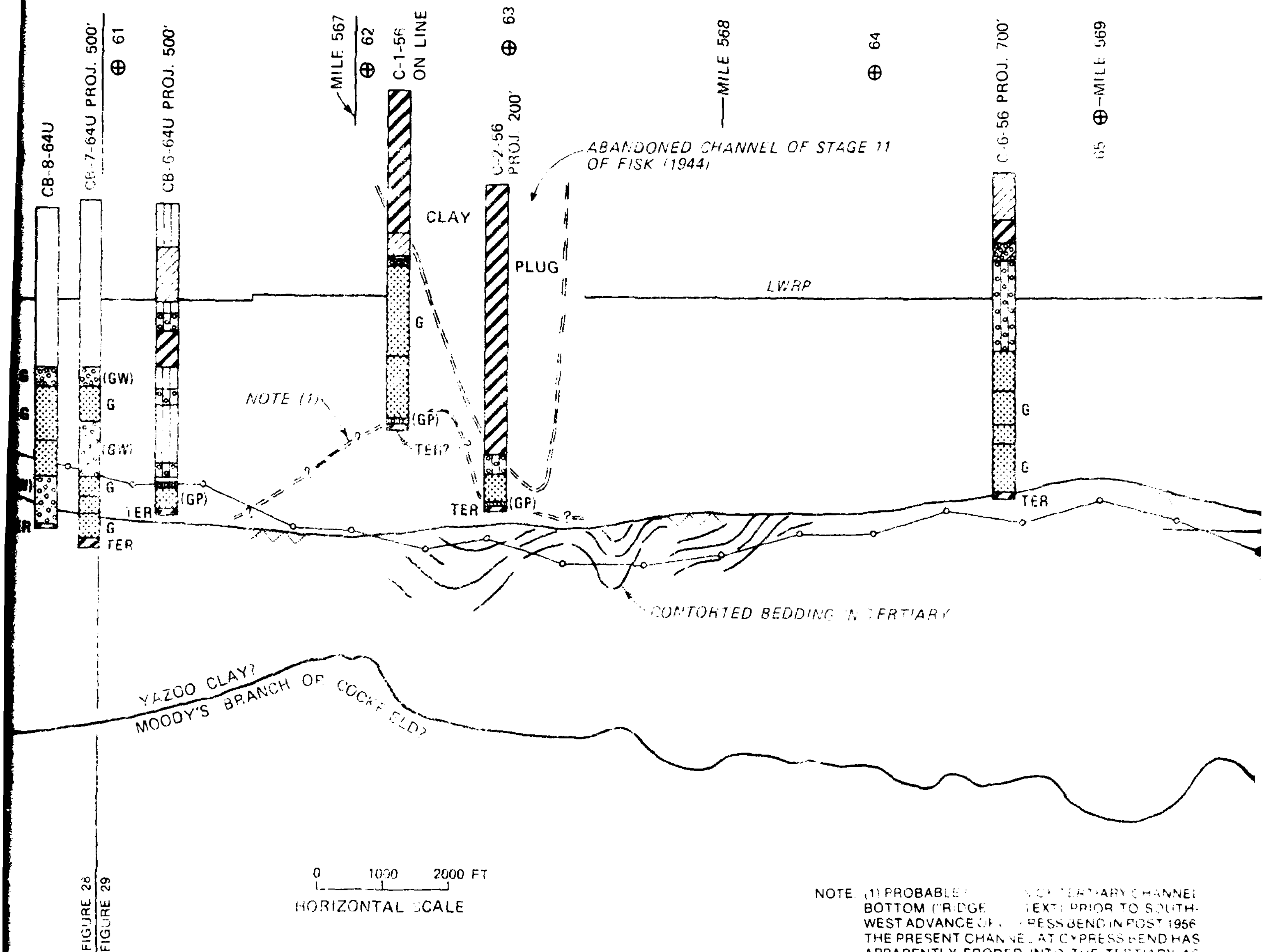
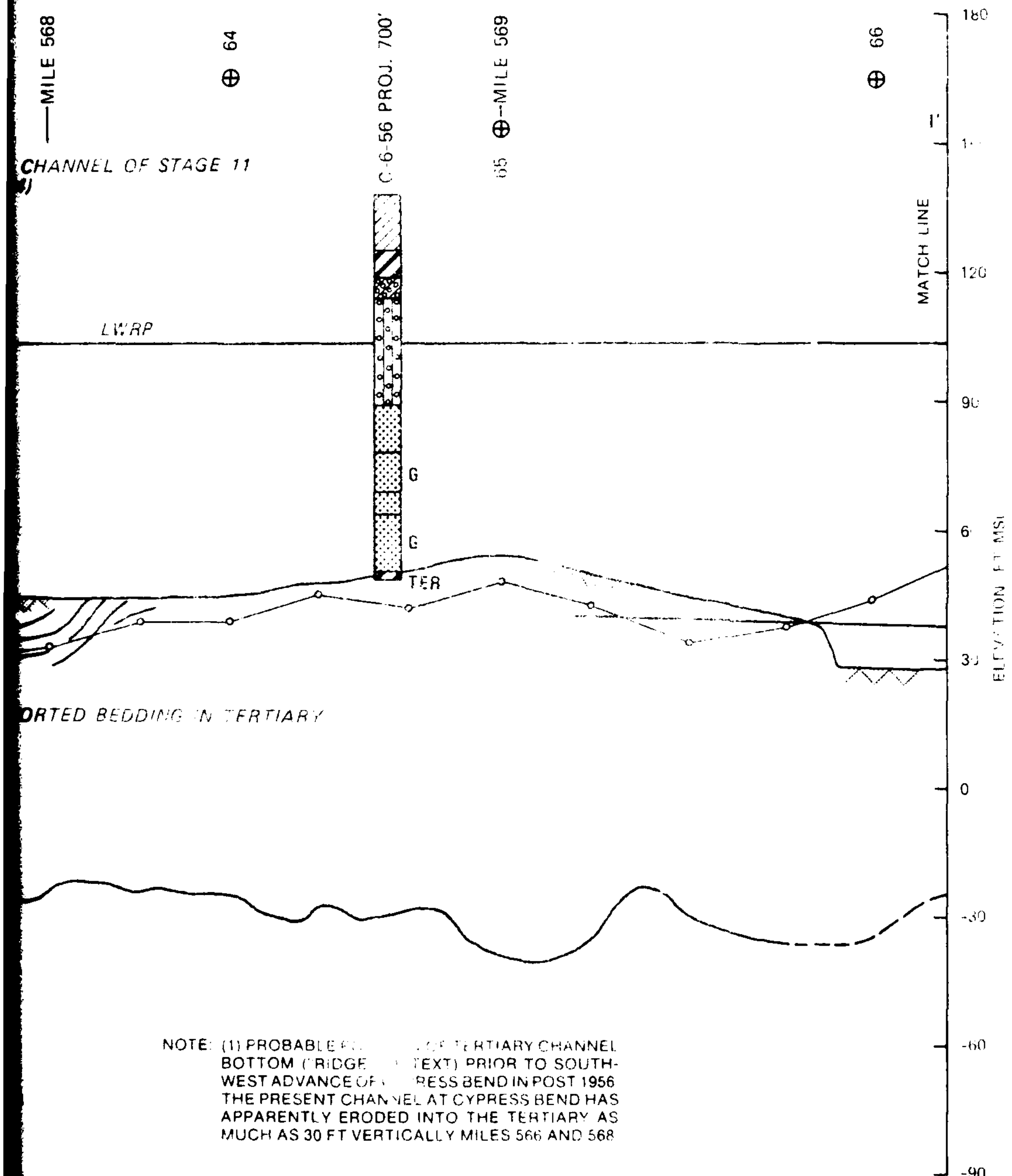


Figure 27. Profile II',



NOTE. (1) PROBABLE ... TERTIARY CHANNEL BOTTOM (RIDGE ... EXT) PRIOR TO SOUTHWEST ADVANCE OF CYPRESS BEND IN POST 1956. THE PRESENT CHANNEL AT CYPRESS BEND HAS APPARENTLY ERODED INTO THE TERTIARY AS MUCH AS 30 FT VERTICALLY MILES 56? AND 568.

re 27. Profile II', Mississippi River, 563.7 to 570.0 MAHP



MILE 568
⊕ 64
C-6-56 PROJ. 700'
⊕ MILE 569
65
⊕ 66
CHANNEL OF STAGE 11
LWRP
MATCH LINE
G
G
TER
ORTED BEDDING IN TERTIARY
180
120
90
0
-30
-60
-90
ELEVATION FT MSL
NOTE: (1) PROBABLE P... OF TERTIARY CHANNEL BOTTOM (RIDGE ... TEXT) PRIOR TO SOUTHWEST ADVANCE OF ... RESS BEND IN POST 1956 THE PRESENT CHANNEL AT CYPRESS BEND HAS APPARENTLY ERODED INTO THE TERTIARY AS MUCH AS 30 FT VERTICALLY MILES 566 AND 568

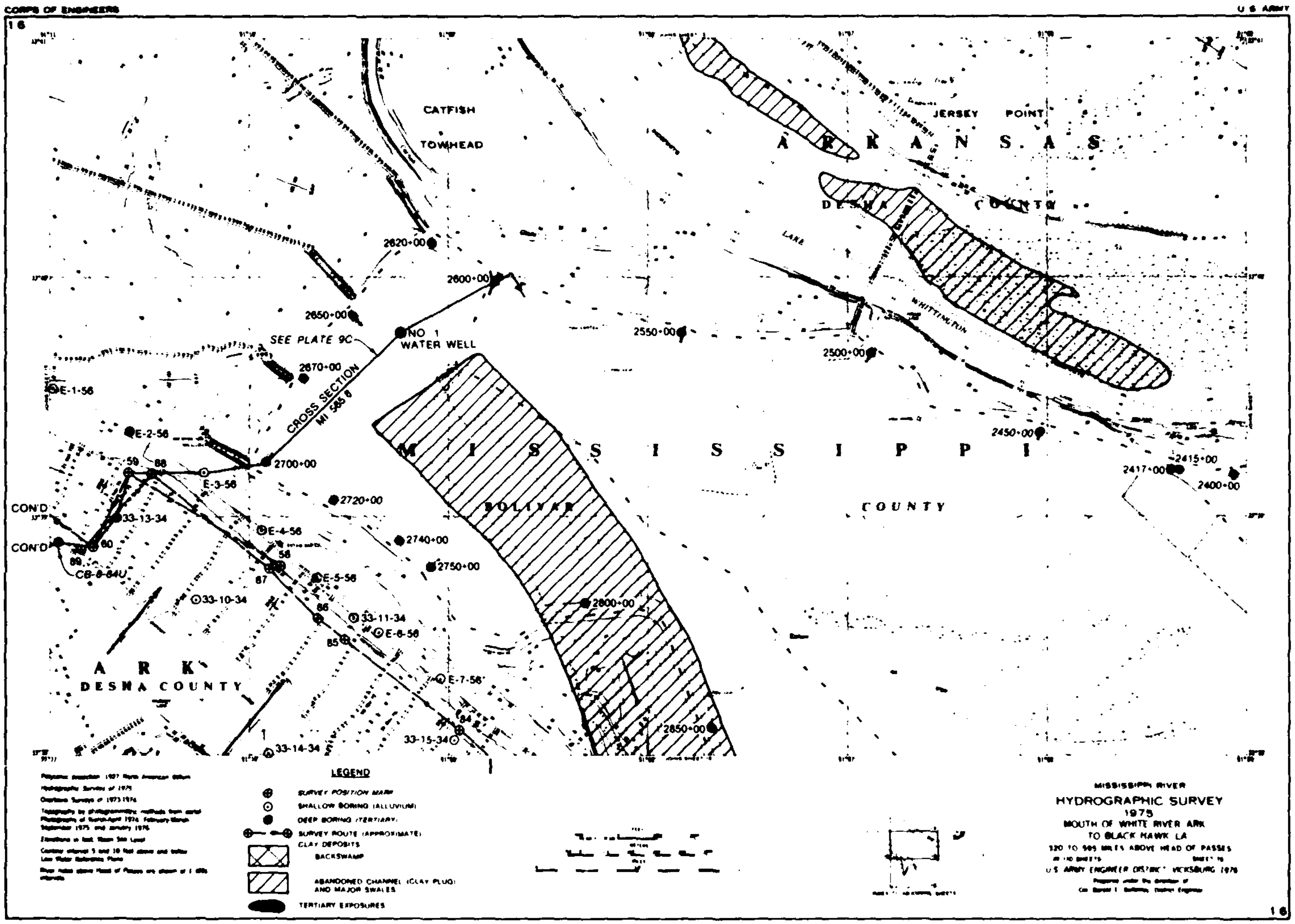


Figure 28. Geologic map, Mississippi River, 563.7 to 566.3 MAHP

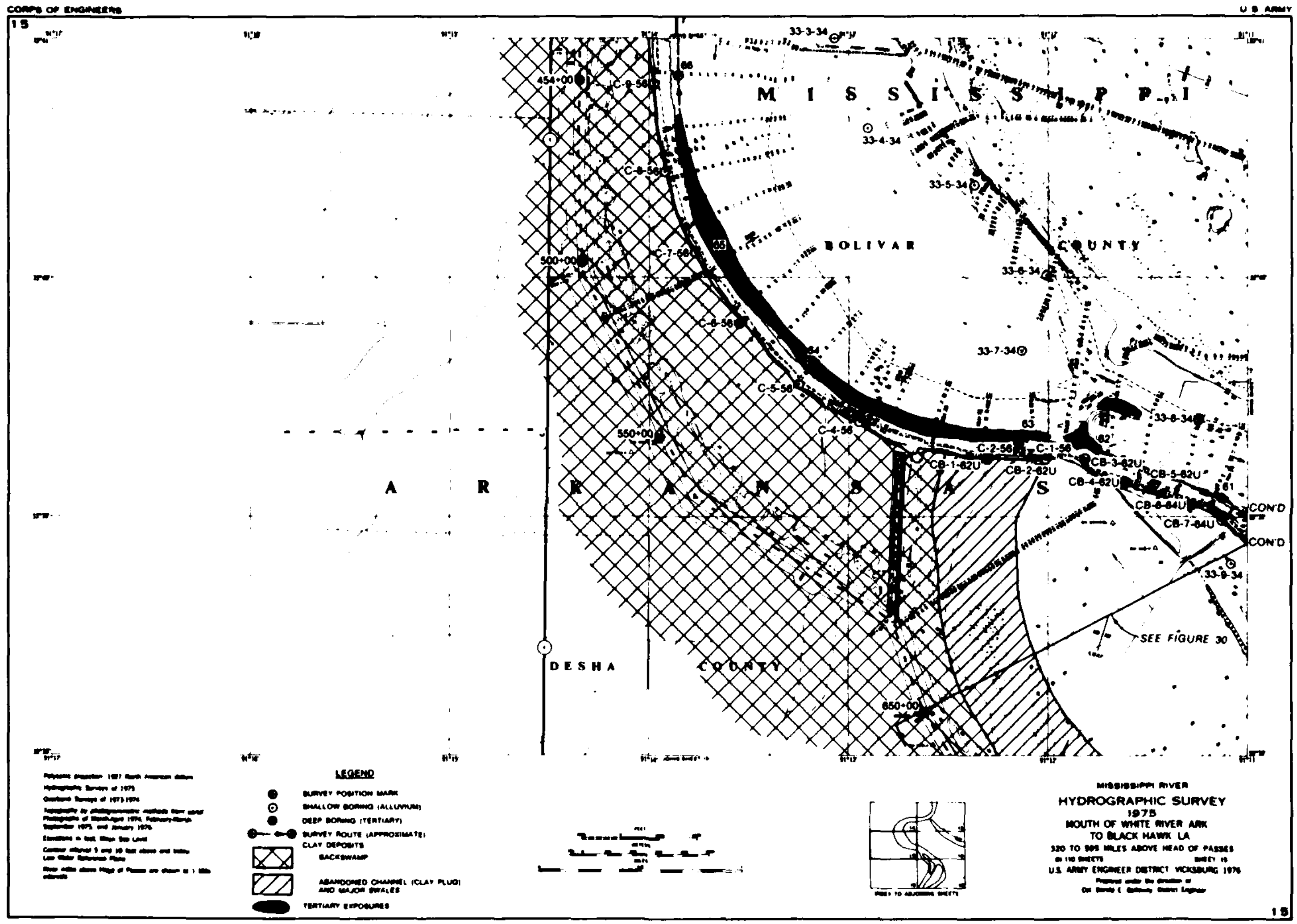


Figure 29. Geologic map, Mississippi River, 566.3 to 570.0 MAHP

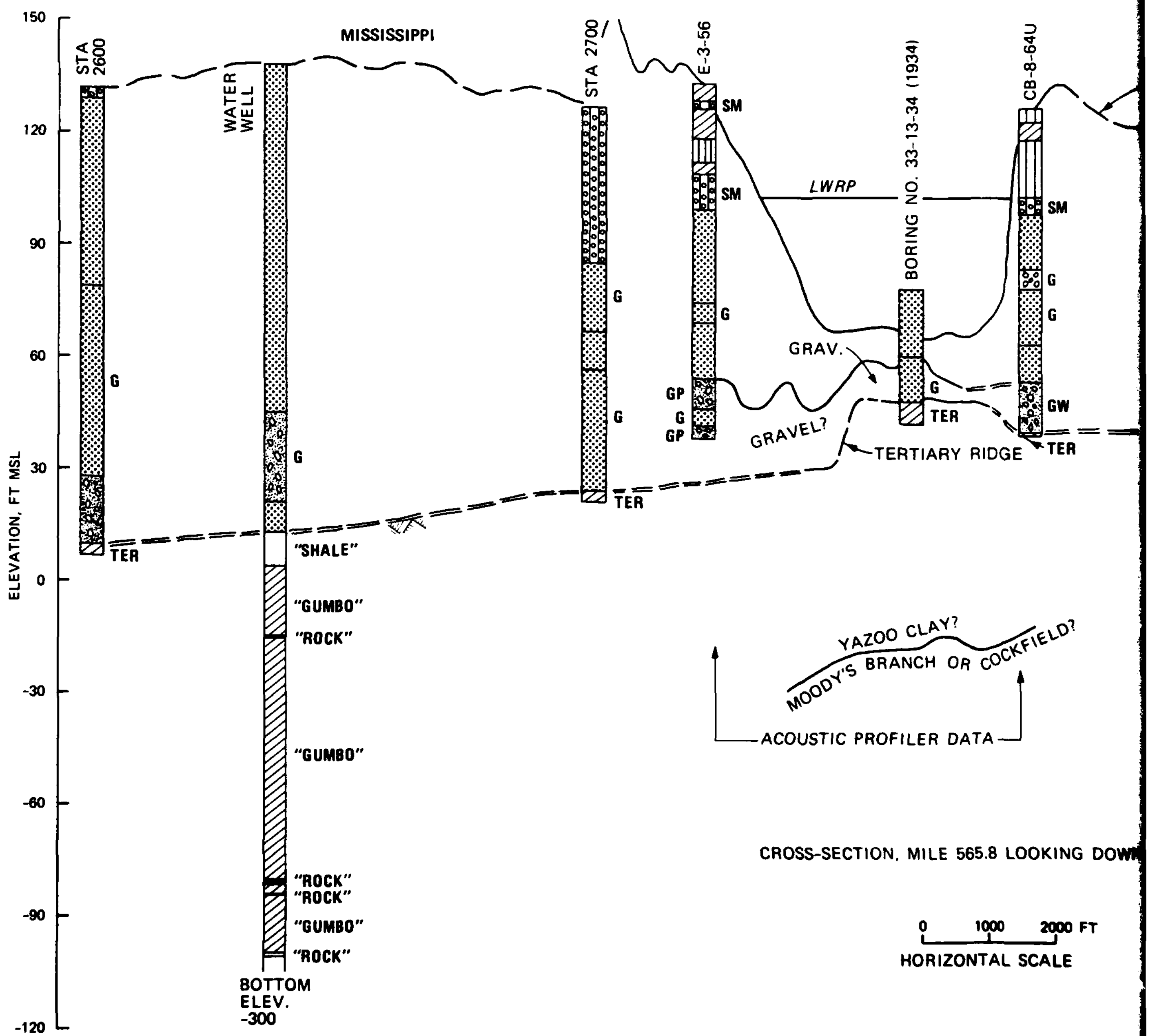
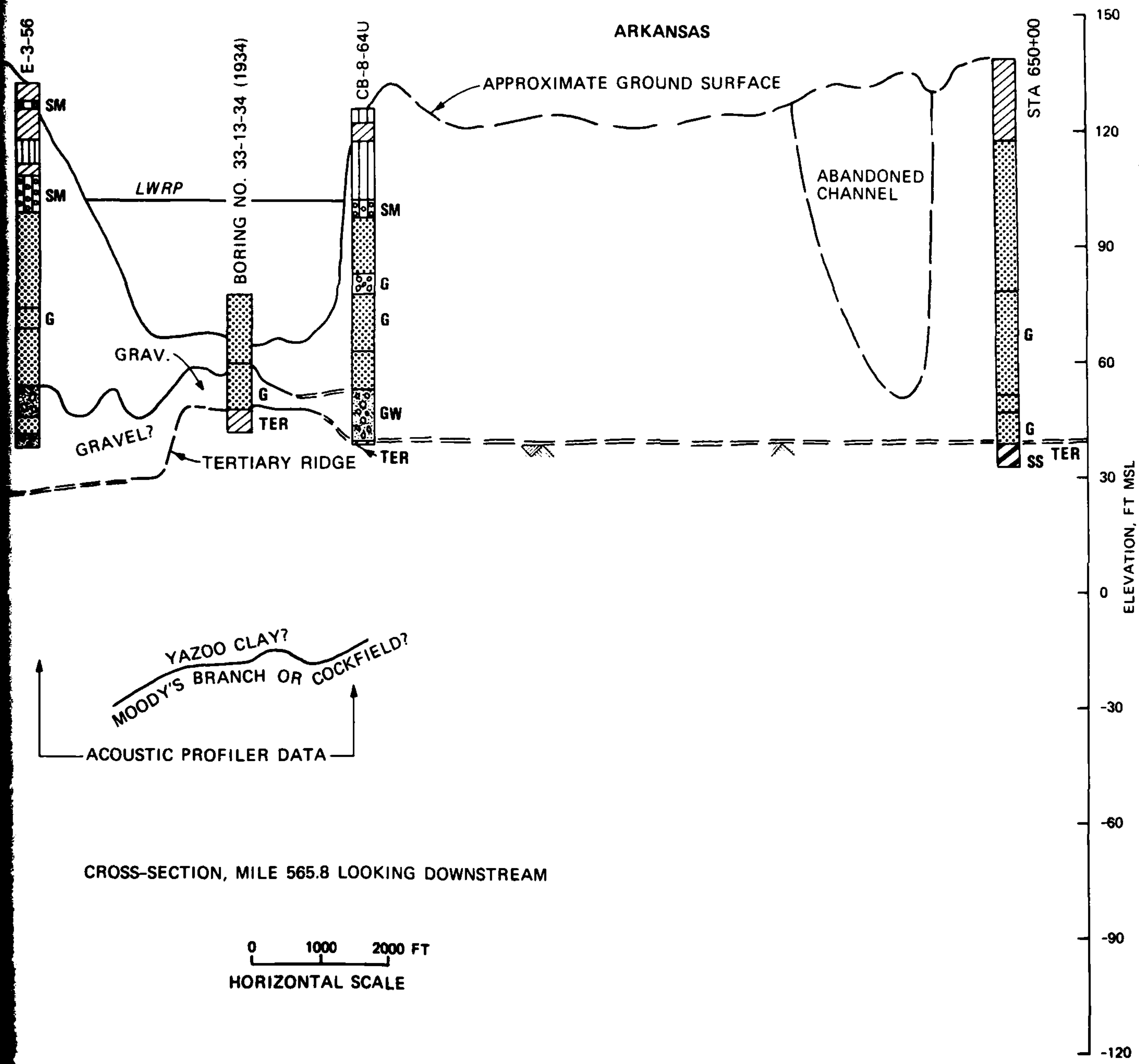
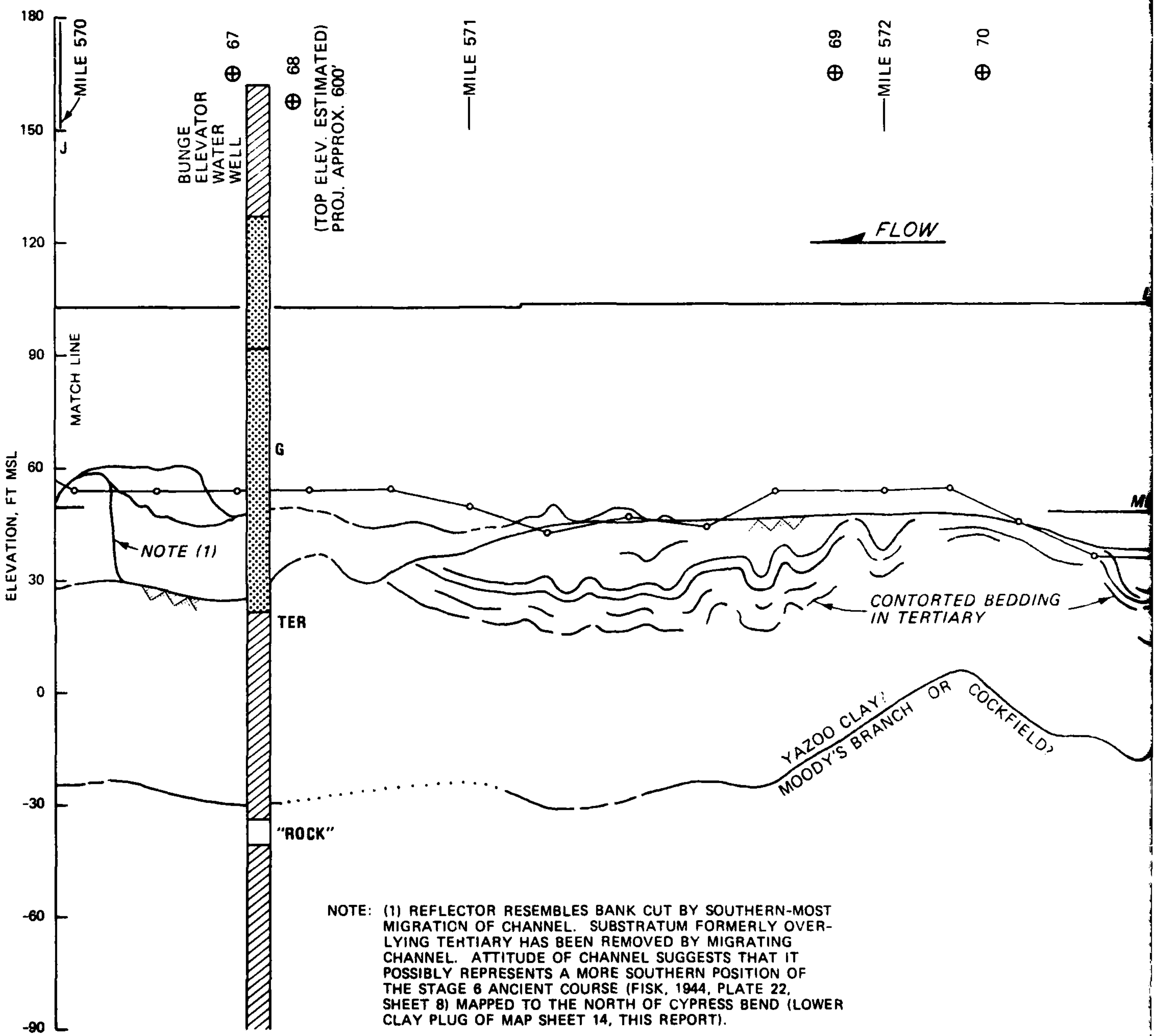


Figure 30. Geologic cross section near Catfish Point, Mississ

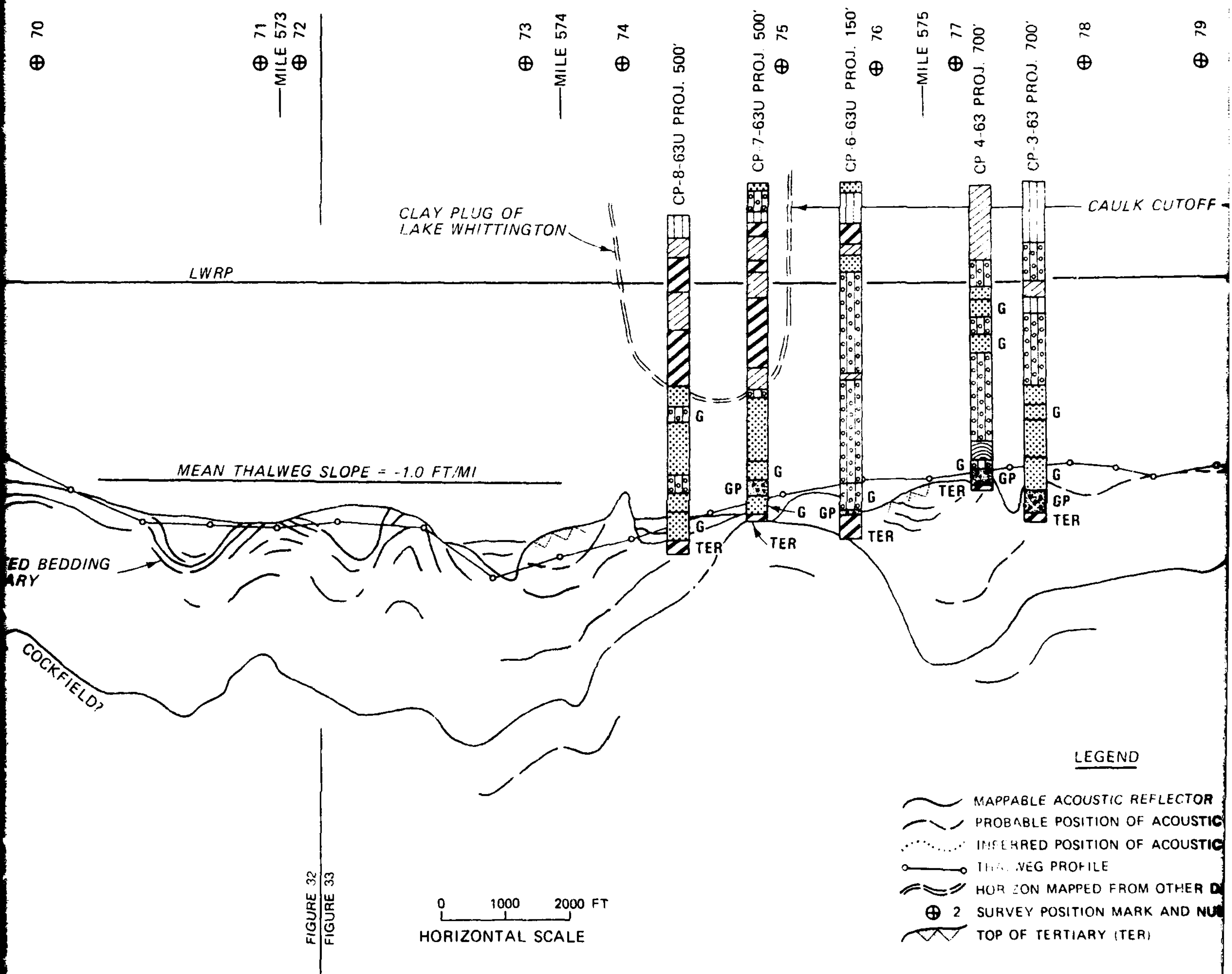


ss section near Catfish Point, Mississippi River, 565.8 MAHP

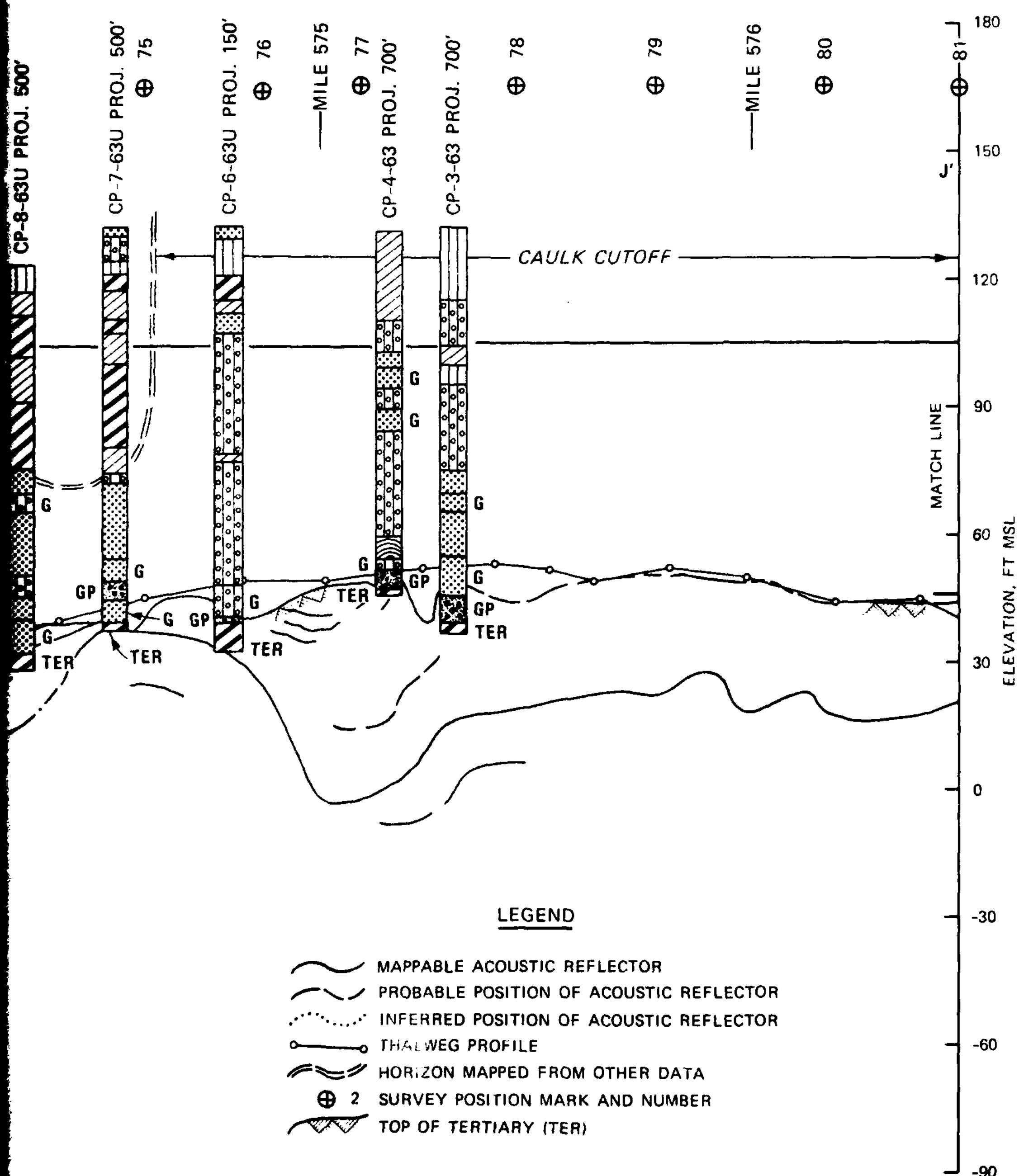


NOTE: (1) REFLECTOR RESEMBLES BANK CUT BY SOUTHERN-MOST MIGRATION OF CHANNEL. SUBSTRATUM FORMERLY OVERLYING TERTIARY HAS BEEN REMOVED BY MIGRATING CHANNEL. ATTITUDE OF CHANNEL SUGGESTS THAT IT POSSIBLY REPRESENTS A MORE SOUTHERN POSITION OF THE STAGE 6 ANCIENT COURSE (FISK, 1944, PLATE 22, SHEET 8) MAPPED TO THE NORTH OF CYPRESS BEND (LOWER CLAY PLUG OF MAP SHEET 14, THIS REPORT).

Figure 31. Profile J



e 31. Profile JJ', Mississippi River, 570.0 to 576.5 MAHP



CP-8-63U PROJ. 500'
CP-7-63U PROJ. 500'
CP-6-63U PROJ. 150'
CP-4-63 PROJ. 700'
CP-3-63 PROJ. 700'
75
76
MILE 575
77
78
79
MILE 576
80
81
J'
CAULK CUTOFF
MATCH LINE
ELEVATION, FT MSL
180
150
120
90
60
30
0
-30
-60
-90
G
GP
TER
LEGEND
MAPPABLE ACOUSTIC REFLECTOR
PROBABLE POSITION OF ACOUSTIC REFLECTOR
INFERRED POSITION OF ACOUSTIC REFLECTOR
THALWEG PROFILE
HORIZON MAPPED FROM OTHER DATA
2 SURVEY POSITION MARK AND NUMBER
TOP OF TERTIARY (TER)

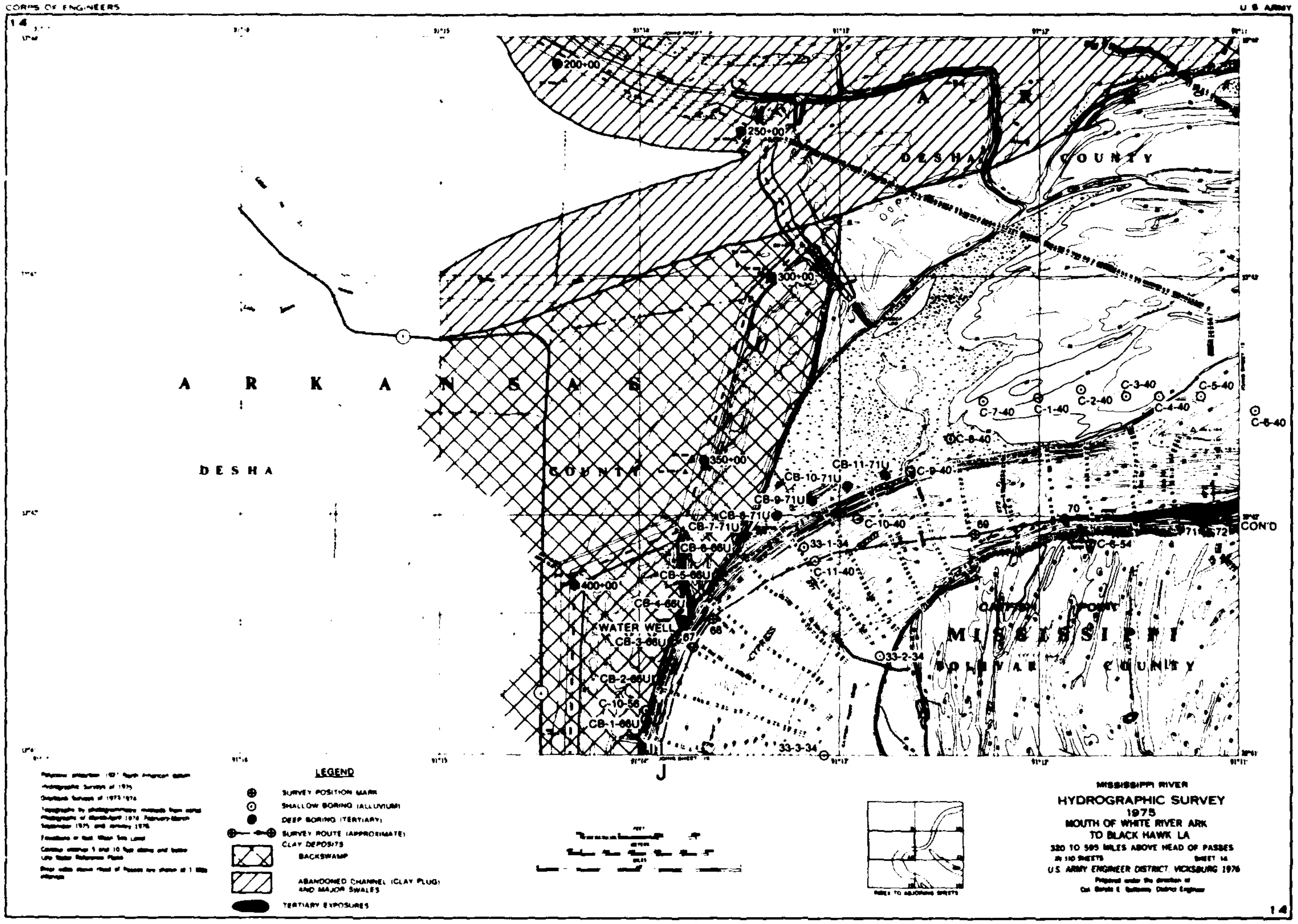


Figure 32. Geologic map, Mississippi River, 570.0 to 573.1 MAHP

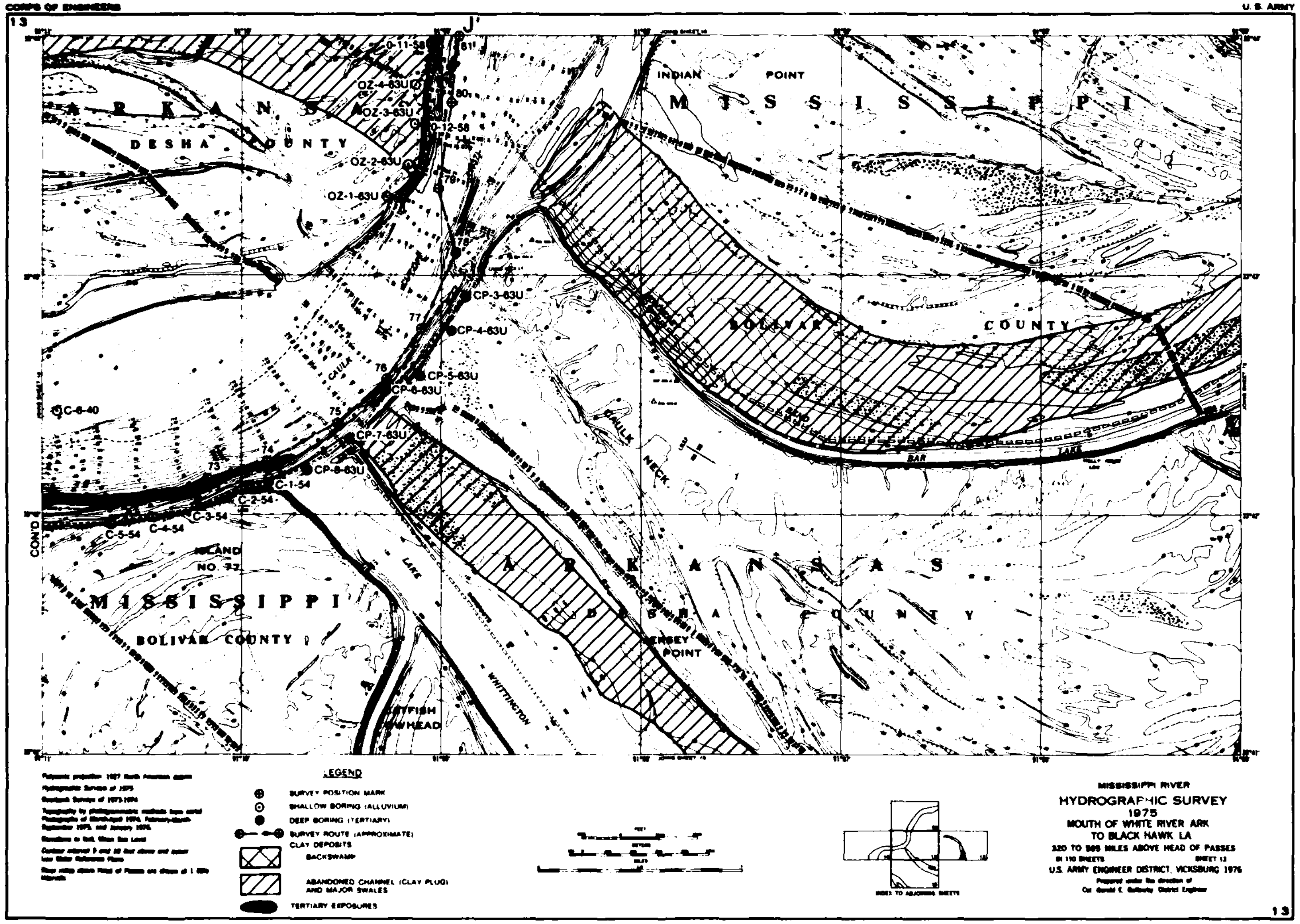
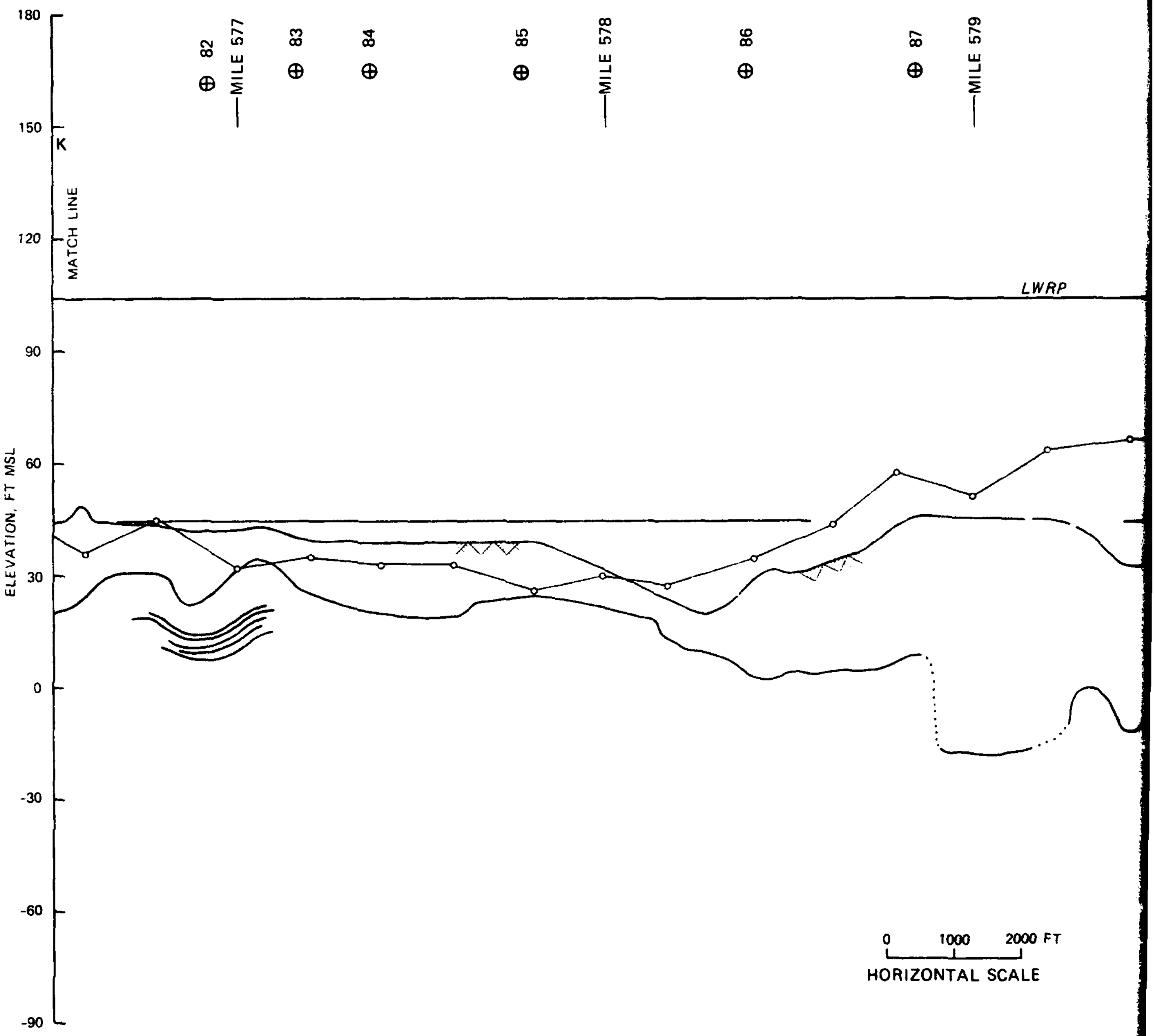


Figure 33. Geologic map, Mississippi River, 573.1 to 576.5 MAHP



180
150
120
90
60
30
0
-30
-60
-90
ELEVATION, FT MSL
K
MATCH LINE
82
MILE 577
83
84
85
MILE 578
86
87
MILE 579
LWRP
0 1000 2000 FT
HORIZONTAL SCALE

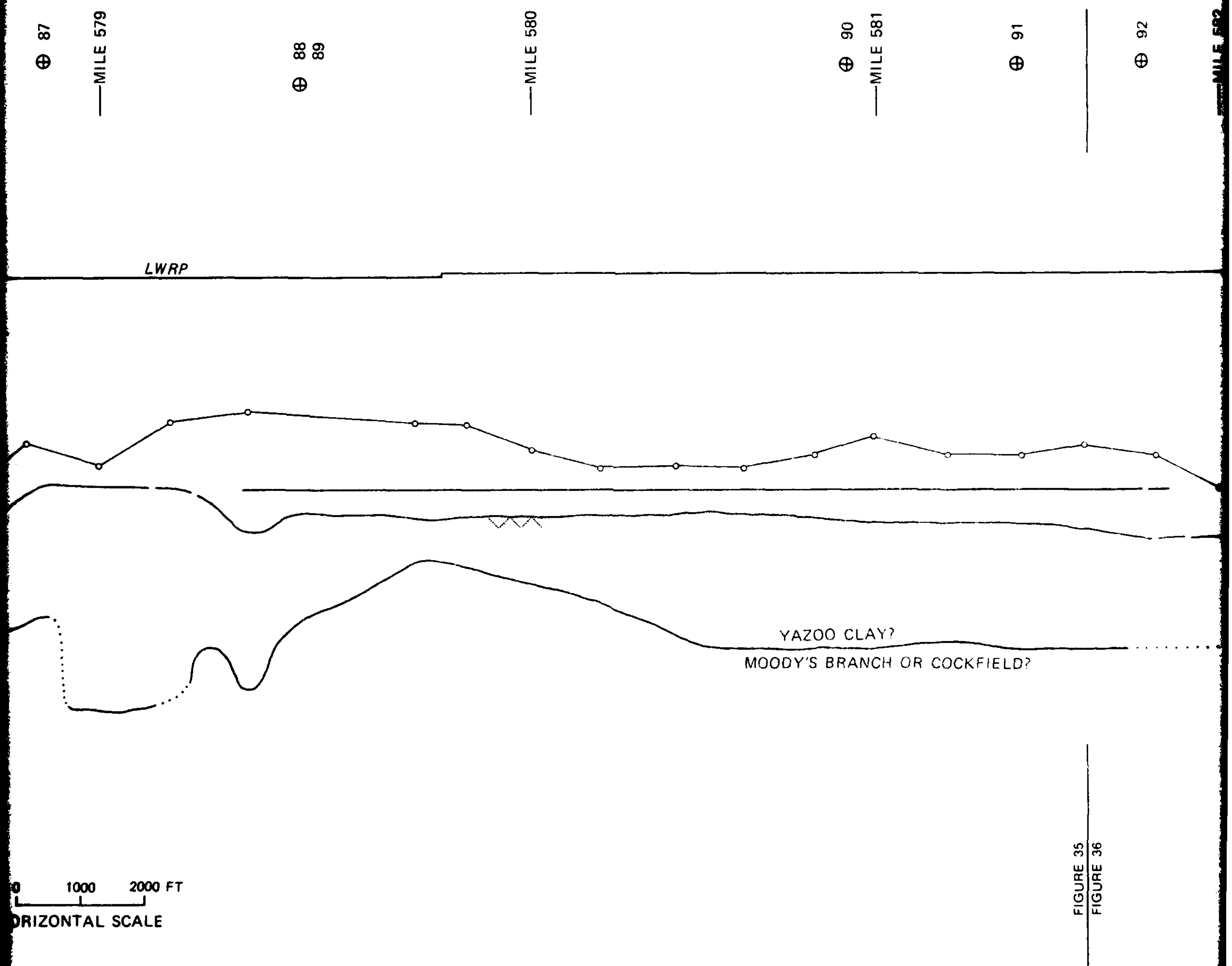
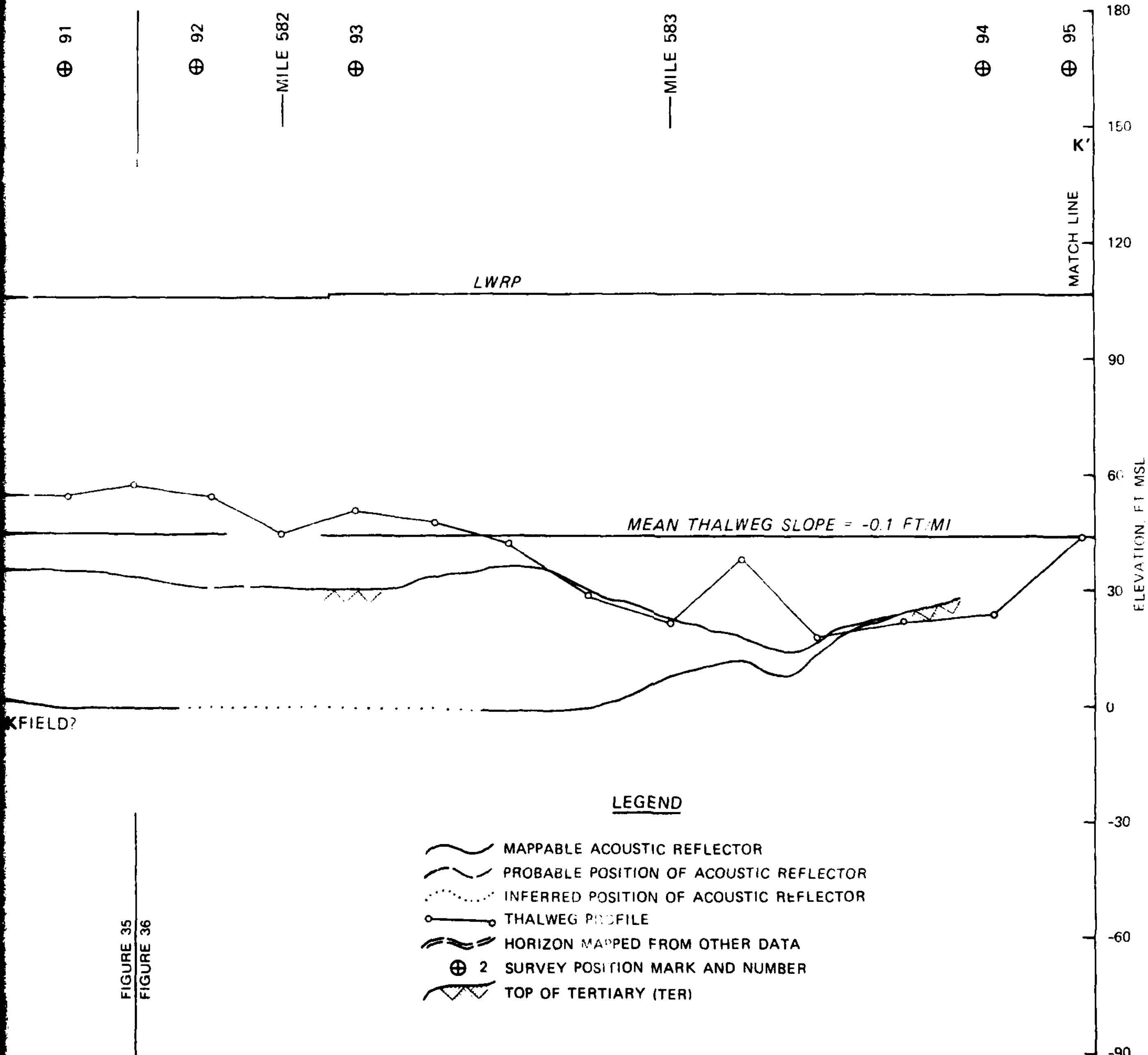


Figure 34. Profile KK', Mississippi R ver, 576.5 to 583.8 MAHP



⊕ 91
⊕ 92
MILE 582
⊕ 93
MILE 583
⊕ 94
⊕ 95
K'
MATCH LINE
LWRP
MEAN THALWEG SLOPE = -0.1 FT/MI
KFIELD?
180
150
120
90
60
30
0
-30
-60
-90
ELEVATION, FT MSL
FIGURE 35
FIGURE 36
LEGEND
MAPPABLE ACOUSTIC REFLECTOR
PROBABLE POSITION OF ACOUSTIC REFLECTOR
INFERRED POSITION OF ACOUSTIC REFLECTOR
THALWEG PROFILE
HORIZON MAPPED FROM OTHER DATA
⊕ 2 SURVEY POSITION MARK AND NUMBER
TOP OF TERTIARY (TER)

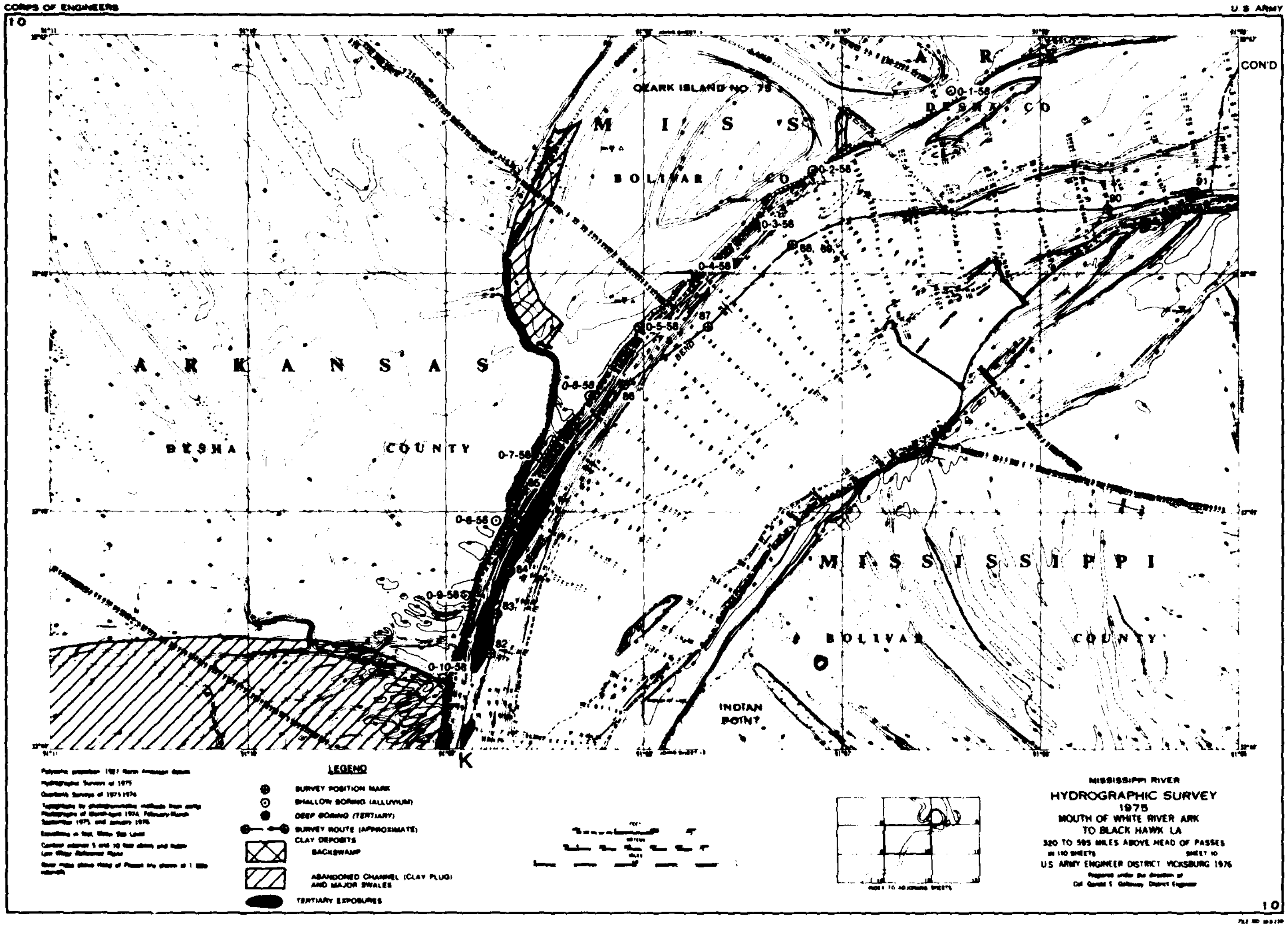


Figure 35. Geologic map, Mississippi River, 576.5 to 581.6 MAHP

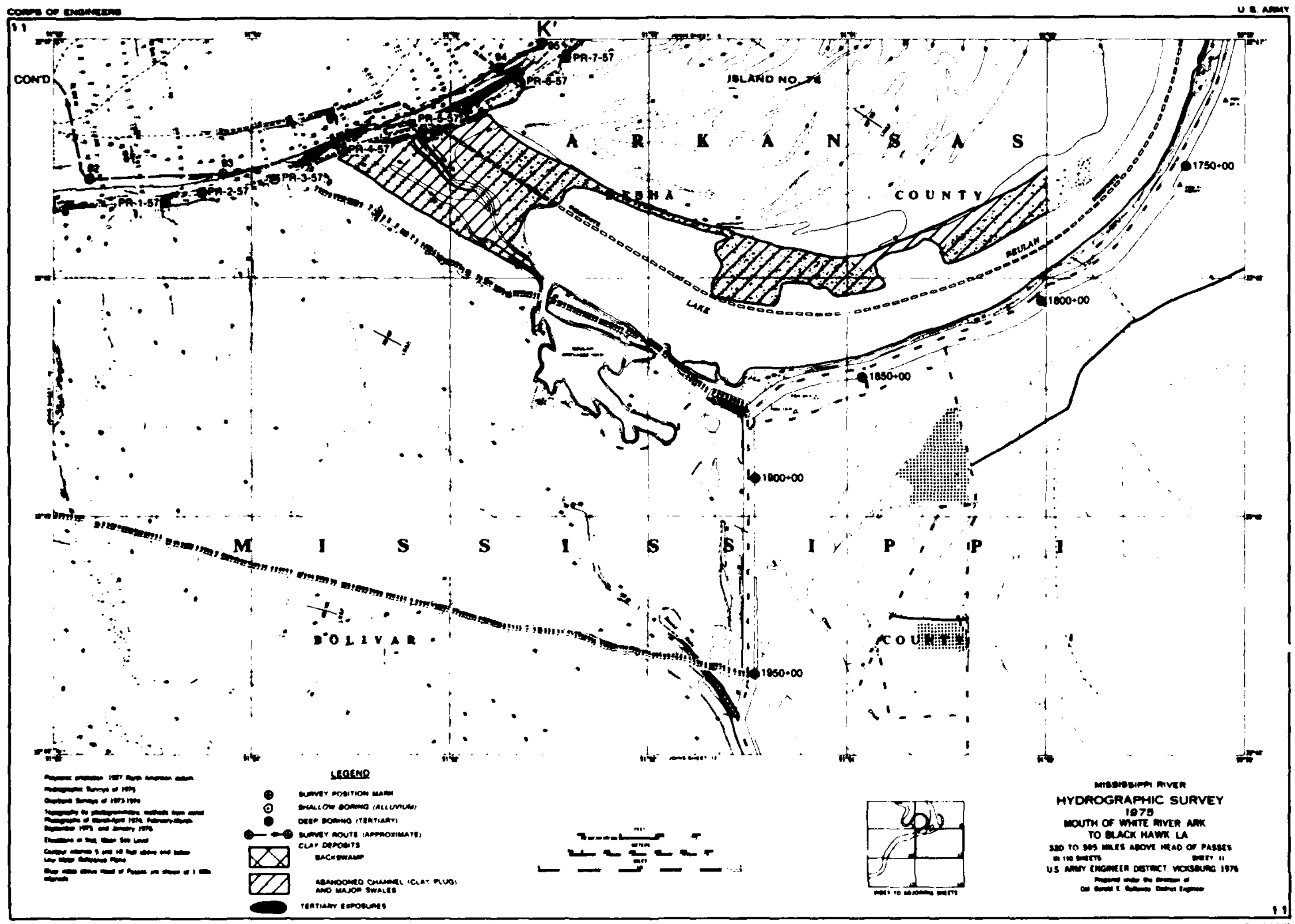


Figure 36. Geologic map, Mississippi River, 581.6 to 583.8 MAHP

AD-A133 099 SURFACE AND SUBSURFACE GEOLOGIC CONDITIONS ALONG SELECTED REACHES OF THE..(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS GEOTE.. W L MURPHY

2/2

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END
DATE
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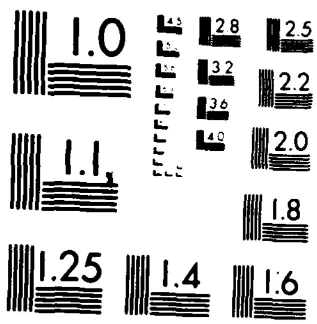
10-83
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

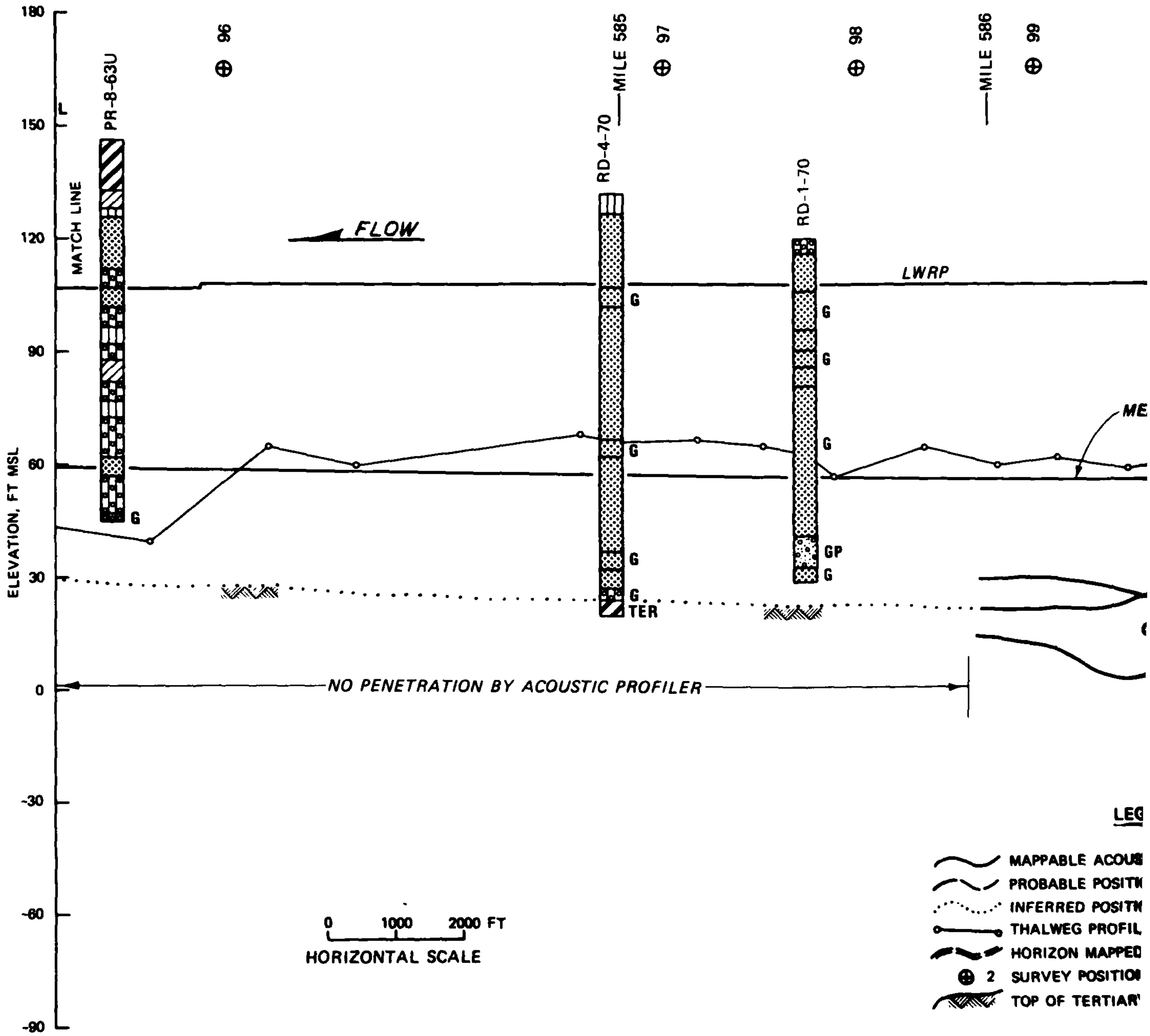
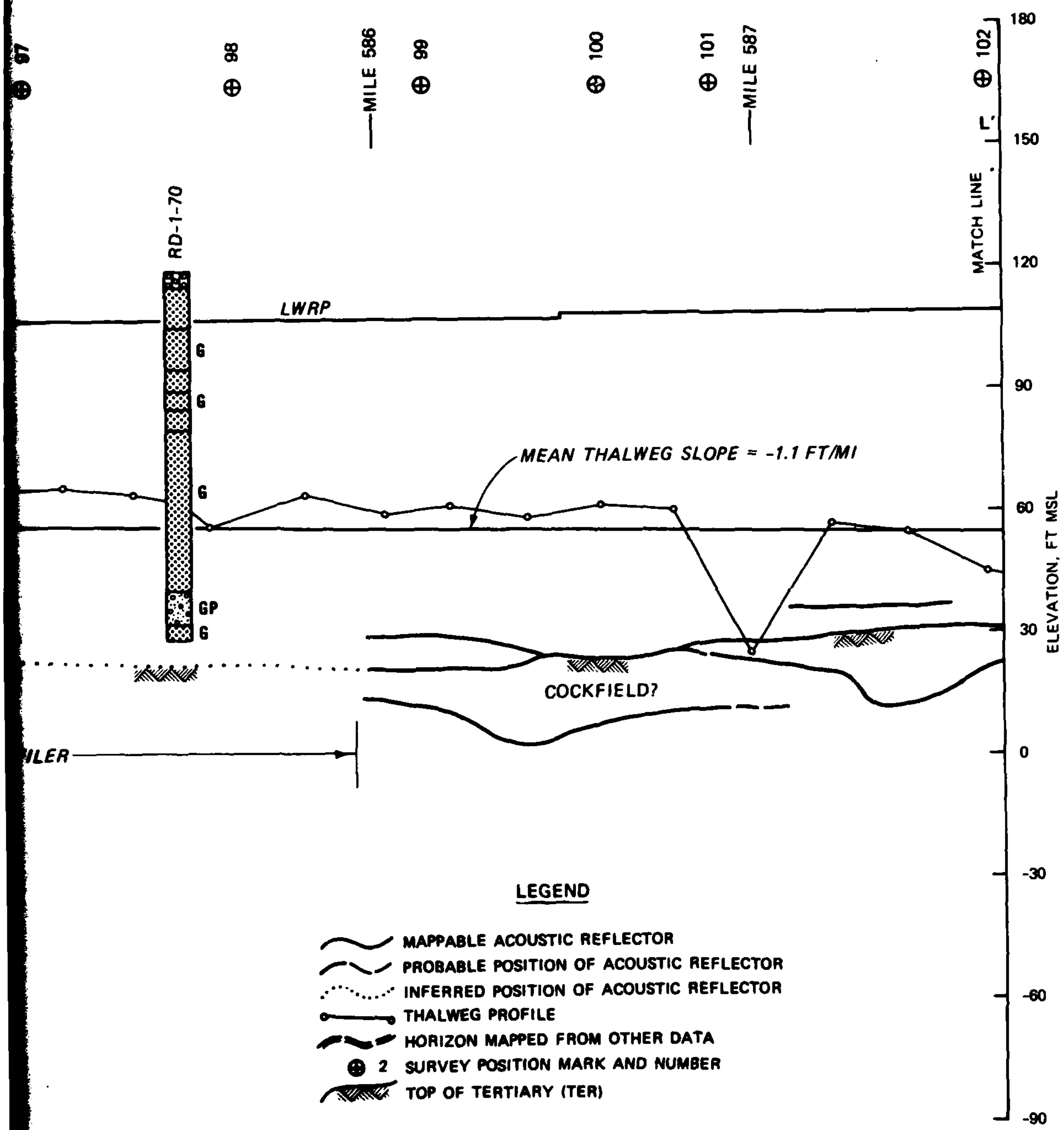


Figure 37. Profile LL', Mississippi River, 583.8 to 587.6 1



LL', Mississippi River, 583.8 to 587.6 MAHP

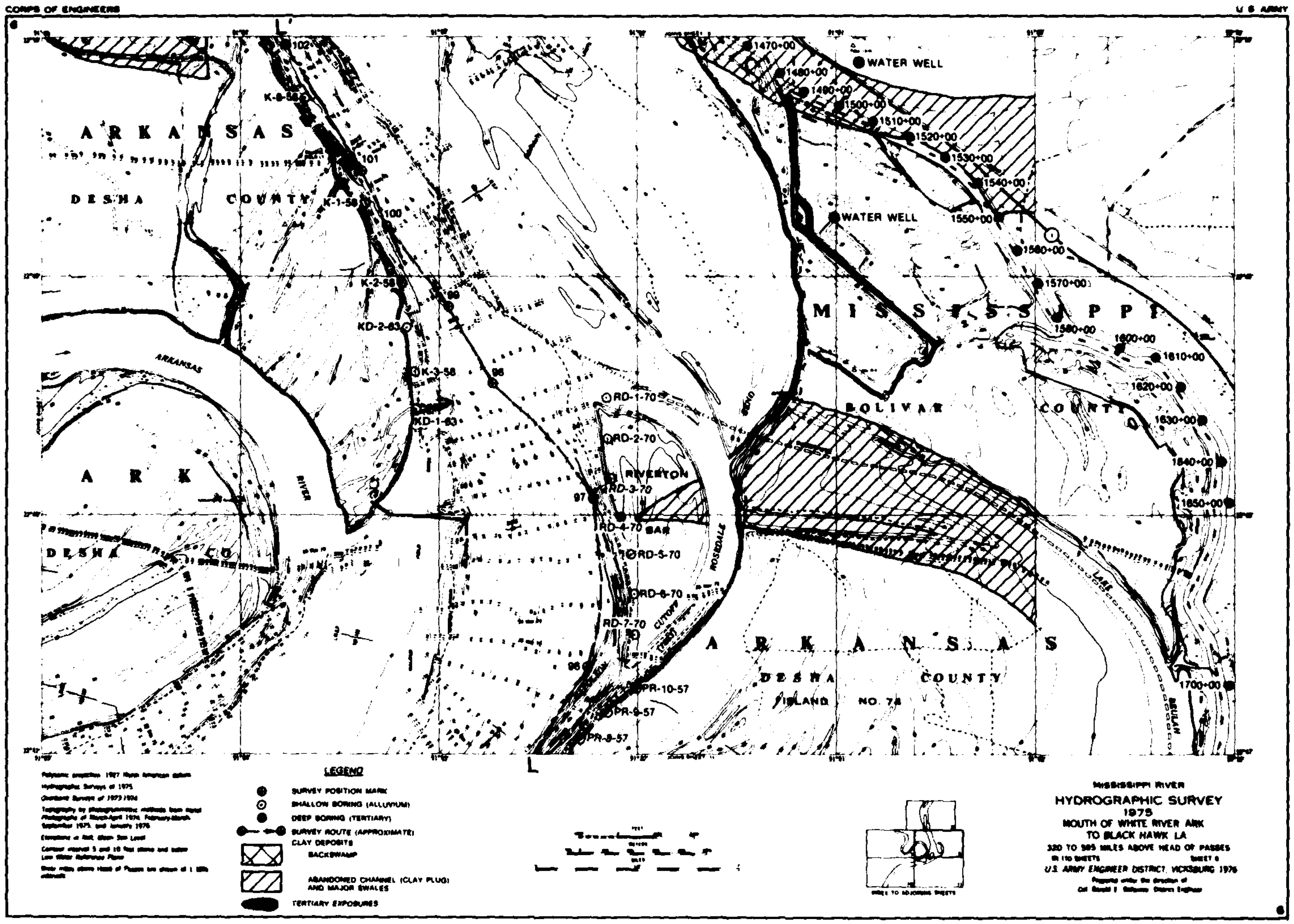


Figure 38. Geologic map, Mississippi River, 583.8 to 587.6 MAHP

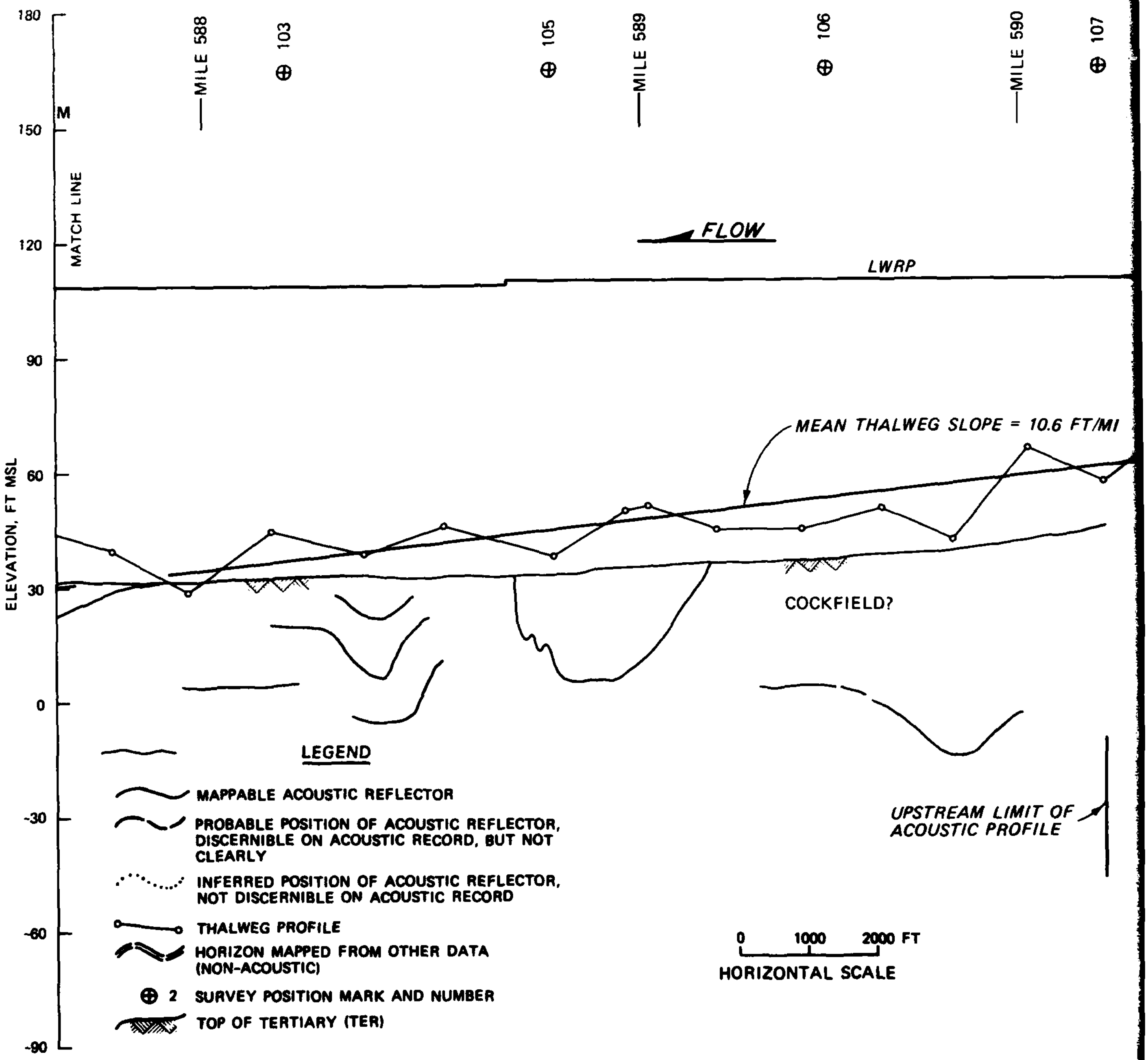
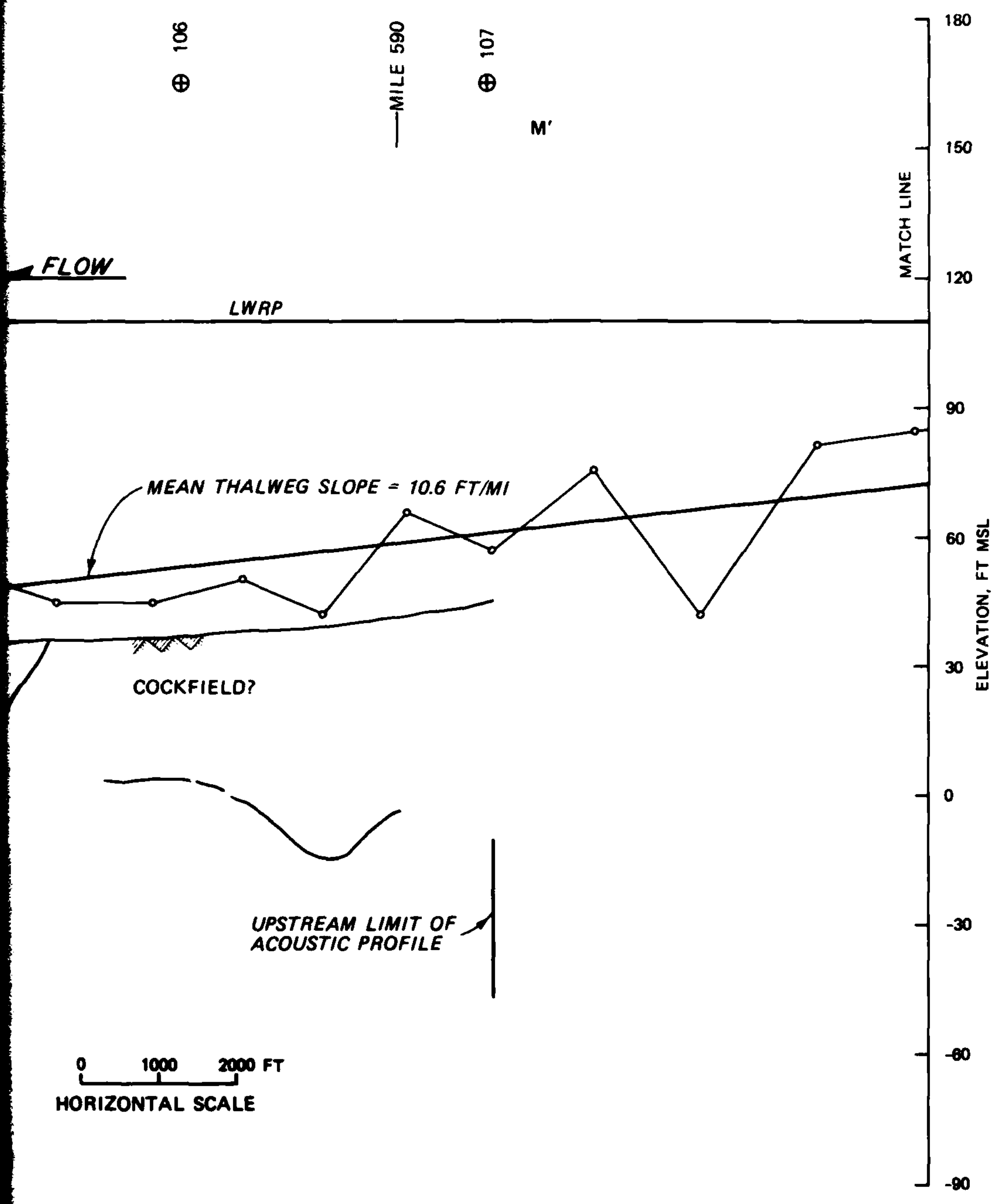


Figure 39. Profile MM', Mississippi River, 587.6 to 590.2 MA



Mississippi River, 587.6 to 590.2 MAHP

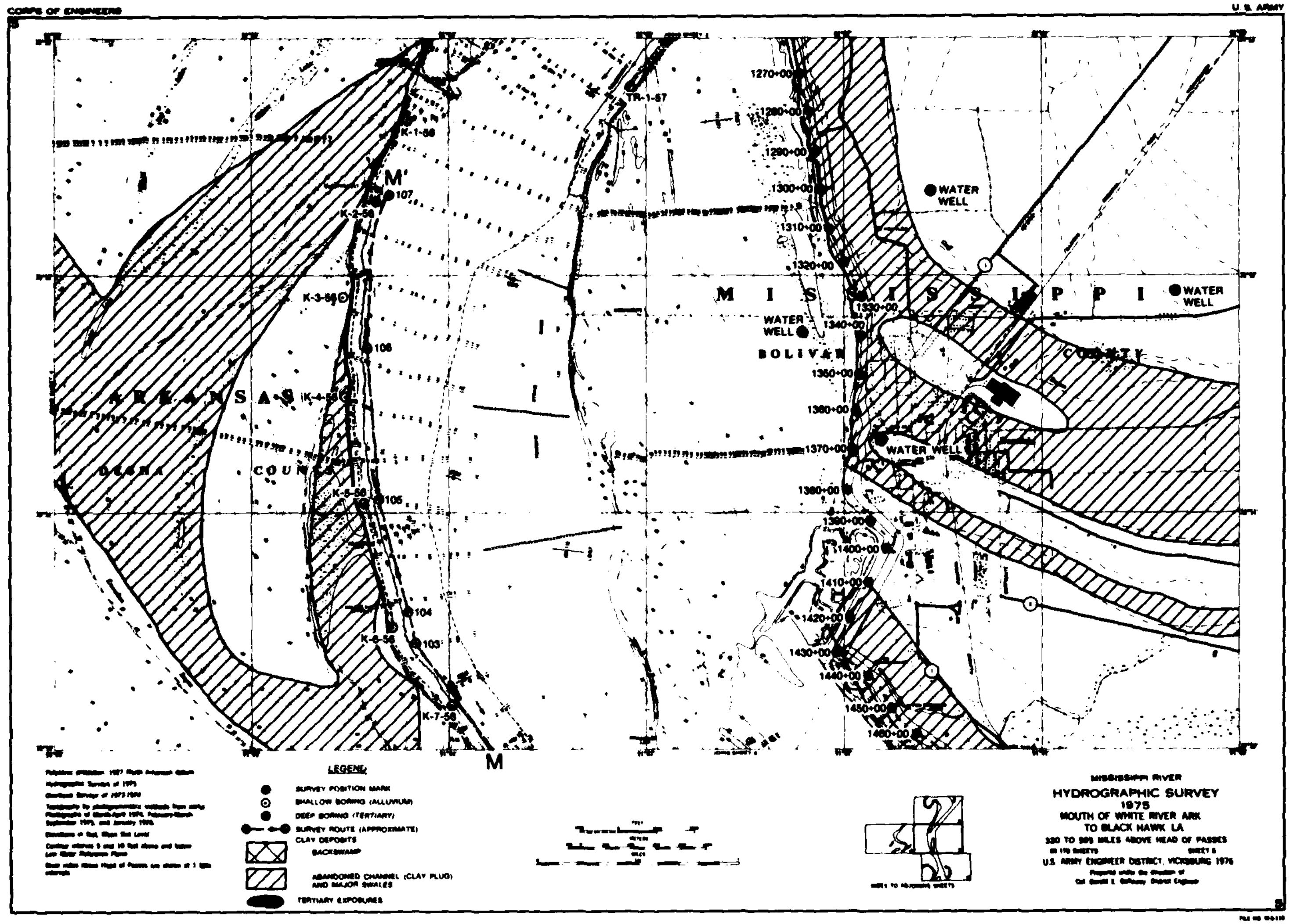


Figure 40. Geologic map, Mississippi River, 587.6 to 591.2 MAHP

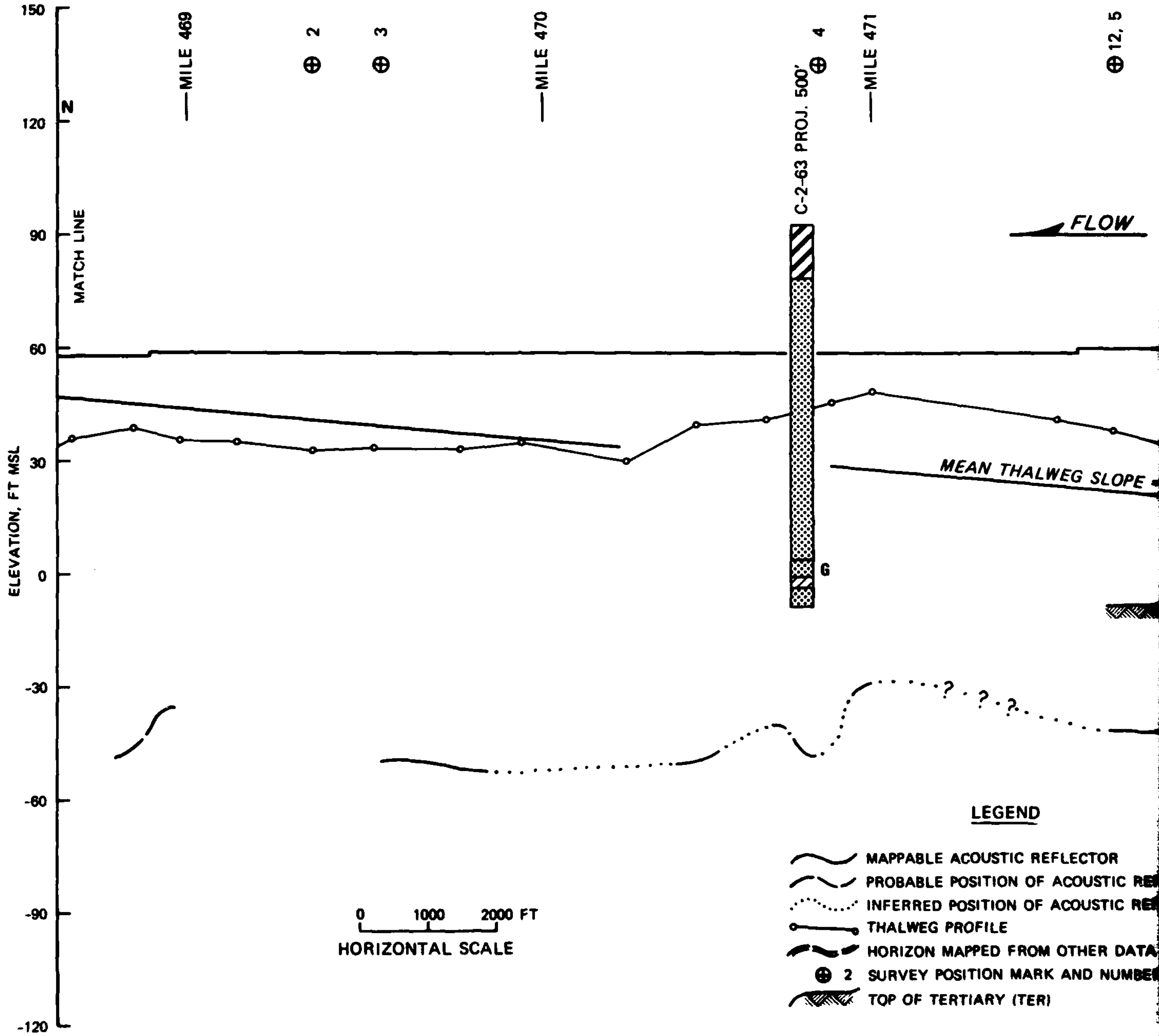
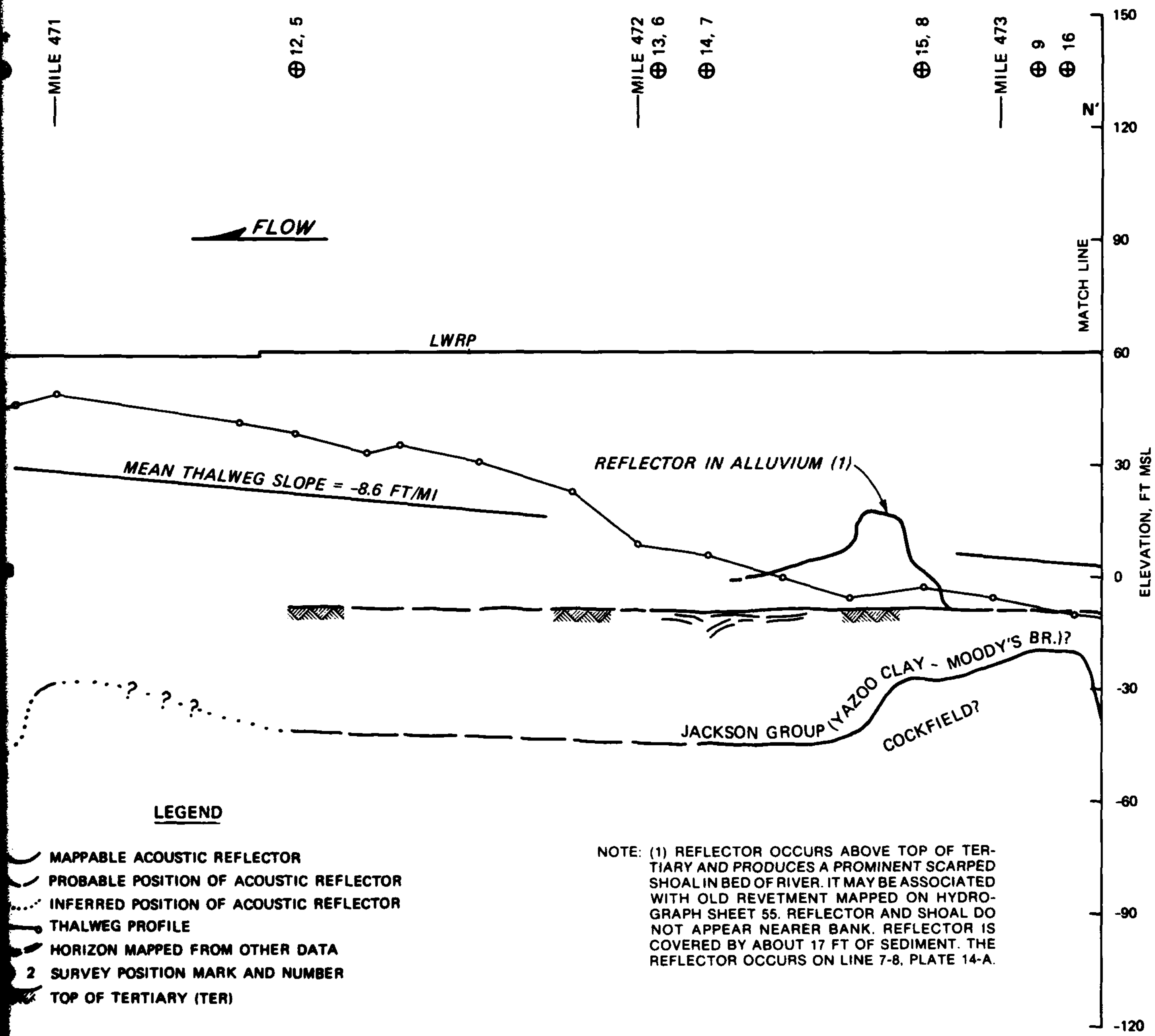


Figure 41. Profile NN', Mississippi River, 4



e NN', Mississippi River, 468.6 to 473.3 MAHP

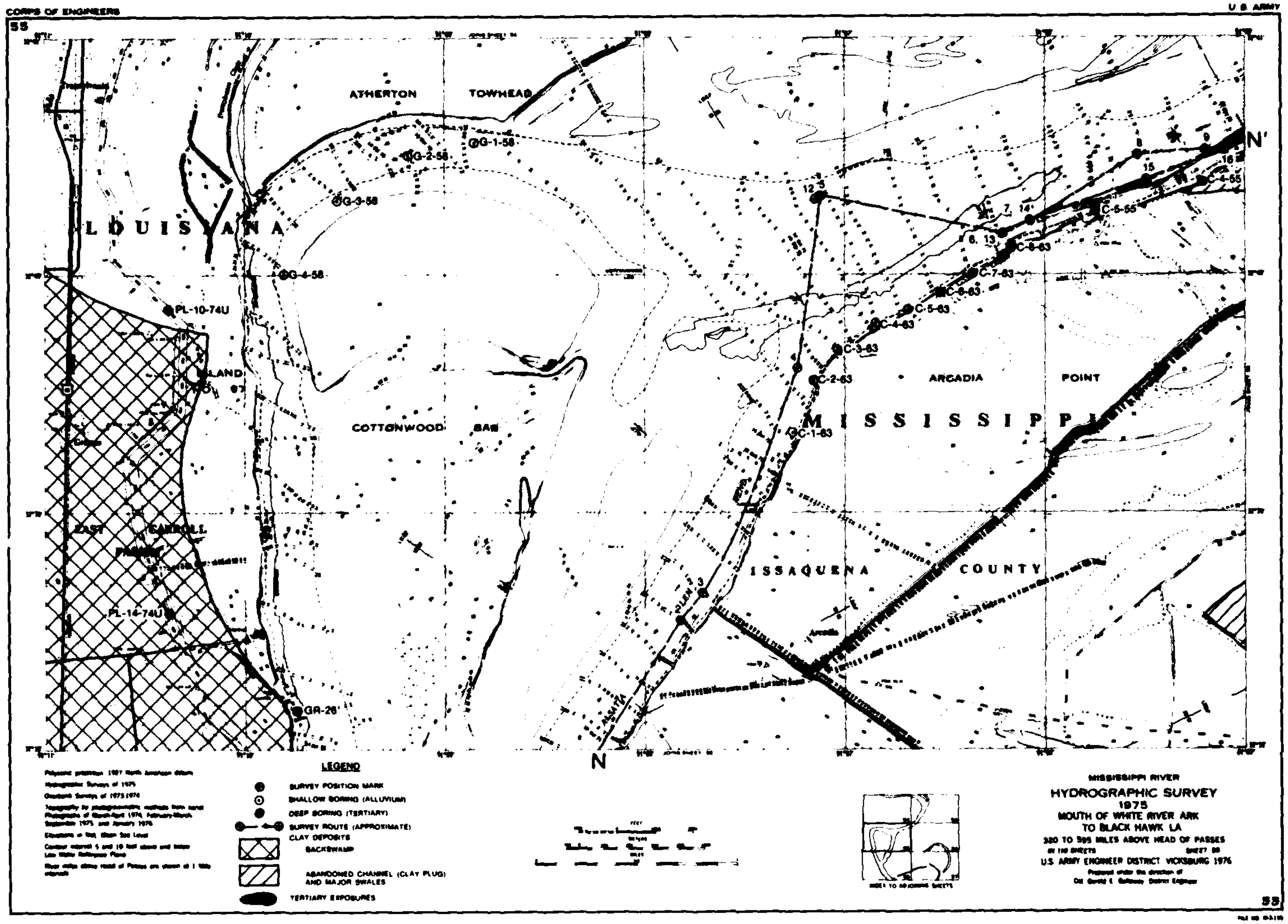


Figure 42. Geologic map, Mississippi River, 468.6 to 473.3 MAHP

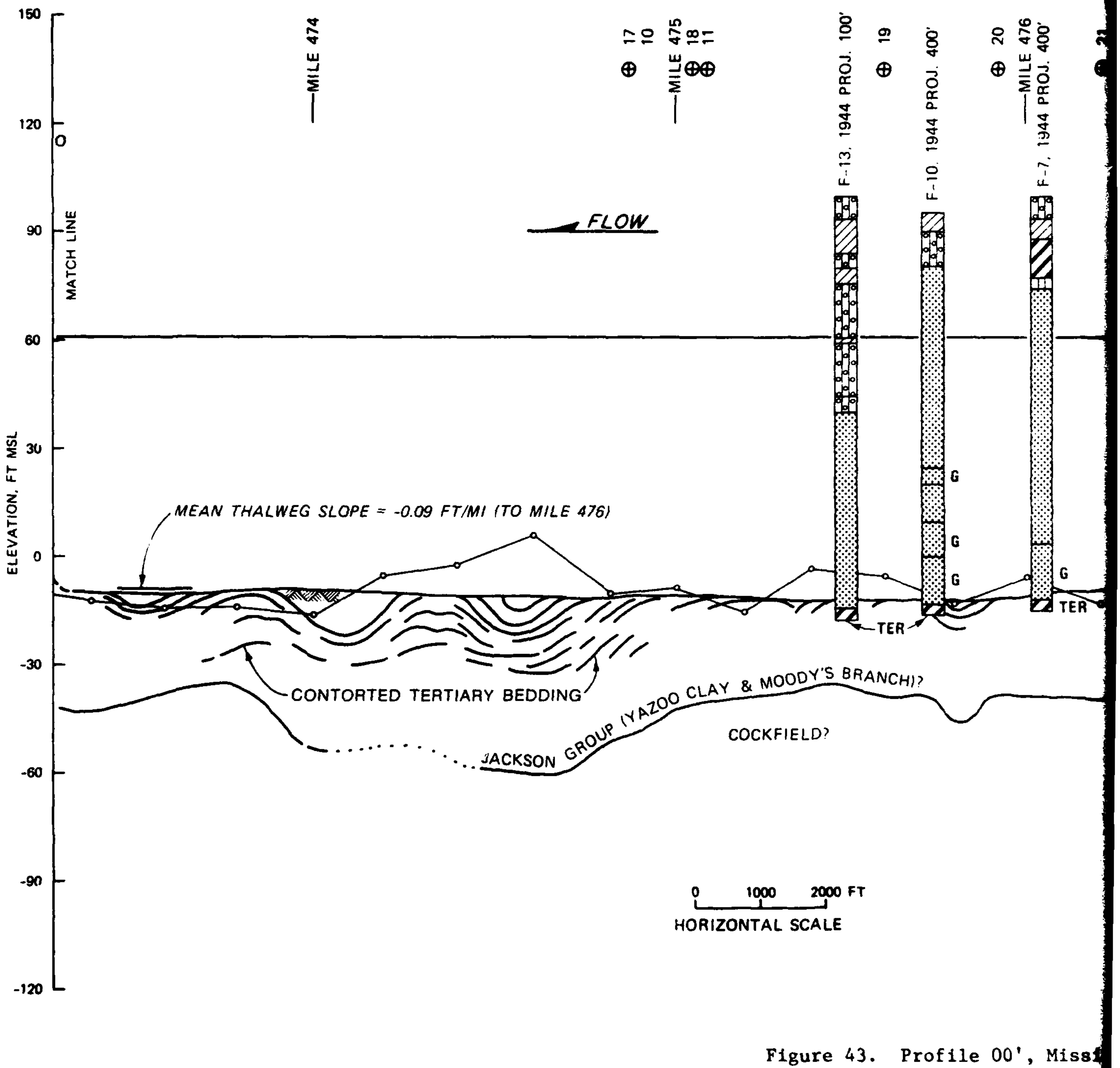
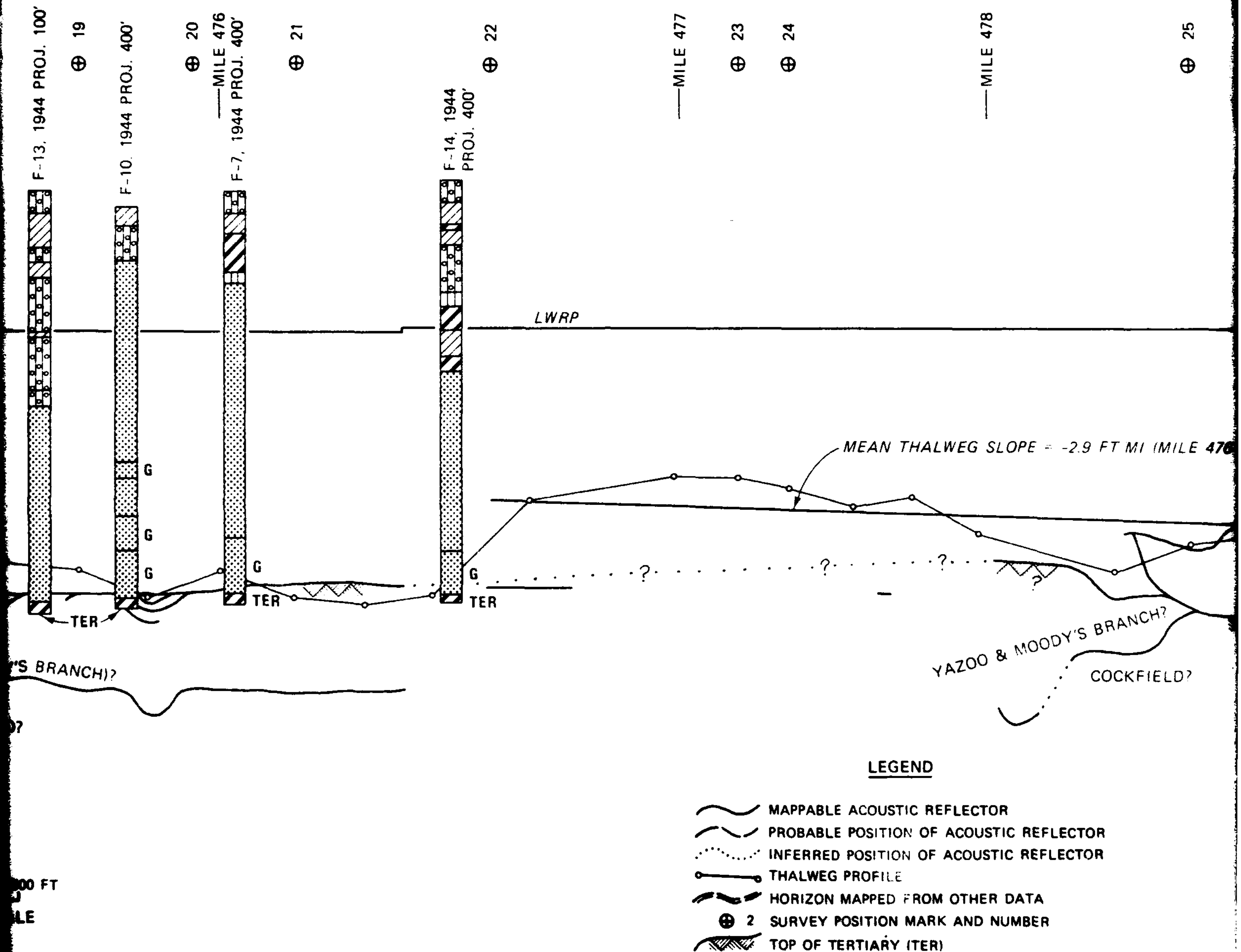
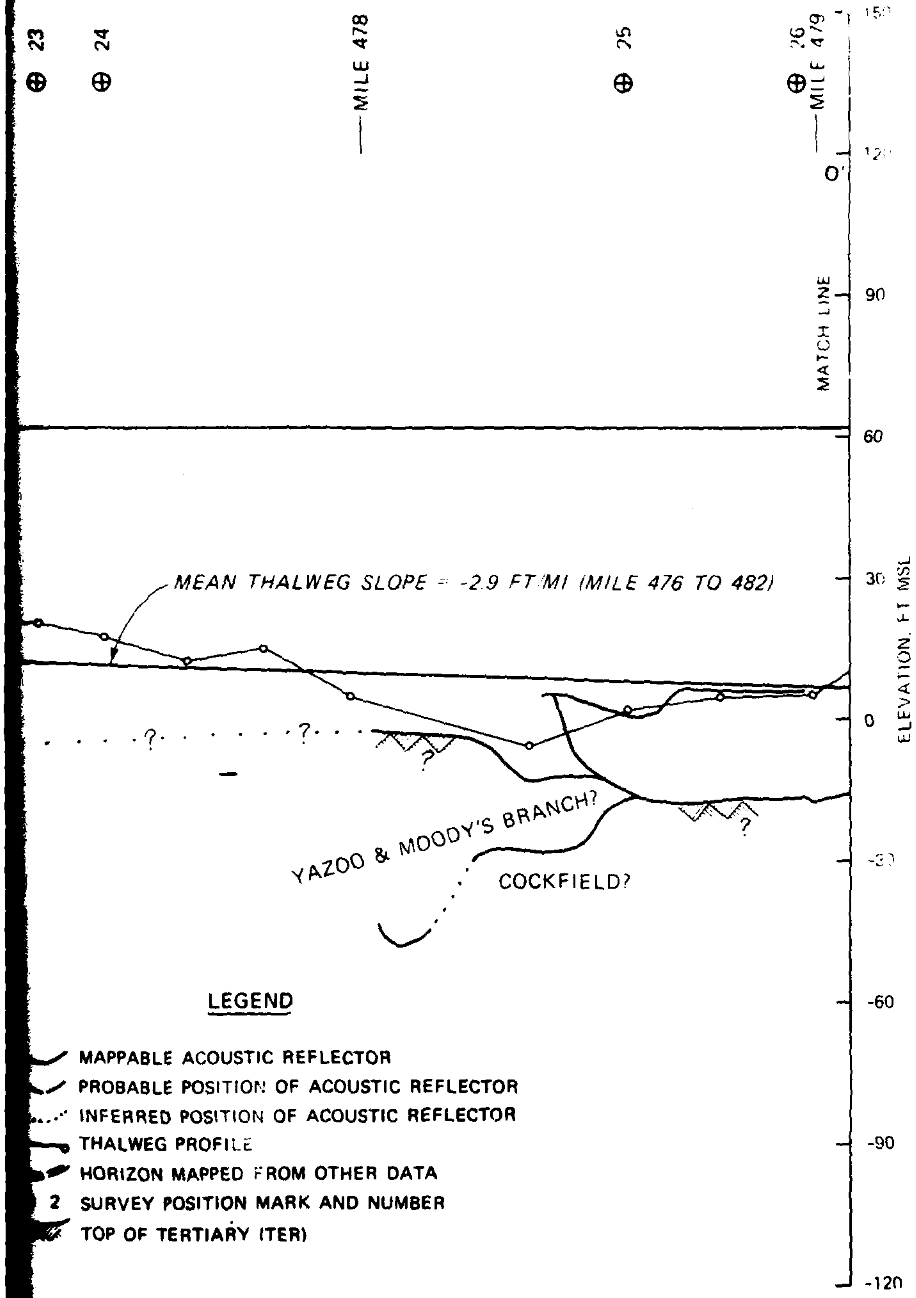


Figure 43. Profile 00', Missi



e 43. Profile 00', Mississippi River, 473.3 to 479.1 MAHP



⊕ 23
⊕ 24
MILE 478
⊕ 25
⊕ 26
MILE 479
O'
MATCH LINE
150
120
90
60
30
0
-30
-60
-90
-120
ELEVATION, FT MSL
MEAN THALWEG SLOPE = -2.9 FT/MI (MILE 476 TO 482)
YAZOO & MOODY'S BRANCH?
COCKFIELD?
LEGEND
MAPPABLE ACOUSTIC REFLECTOR
PROBABLE POSITION OF ACOUSTIC REFLECTOR
INFERRED POSITION OF ACOUSTIC REFLECTOR
THALWEG PROFILE
HORIZON MAPPED FROM OTHER DATA
2 SURVEY POSITION MARK AND NUMBER
TOP OF TERTIARY (TER)

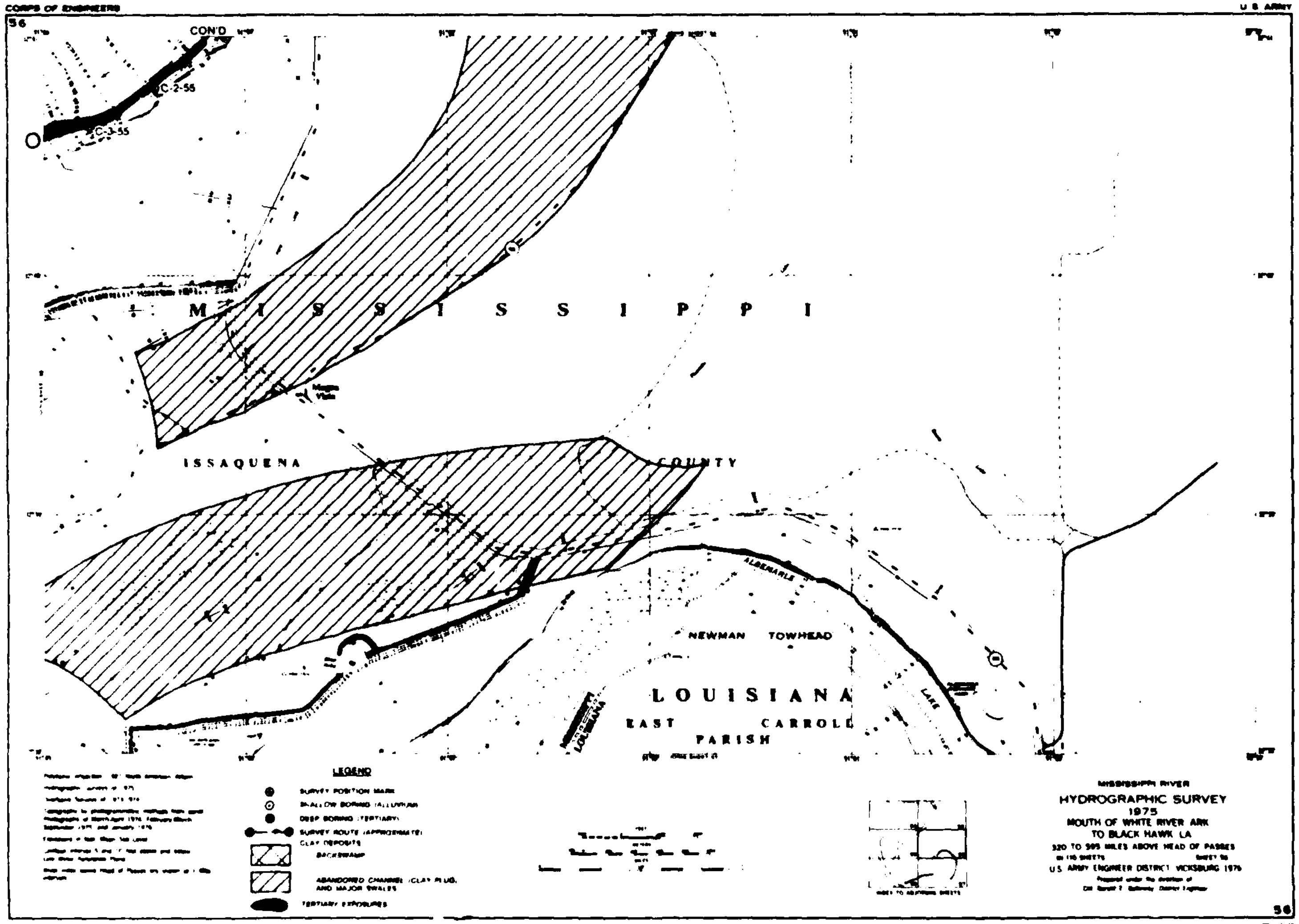


Figure 44. Geologic map, Mississippi River, 473.3 to 474.0 MAHP

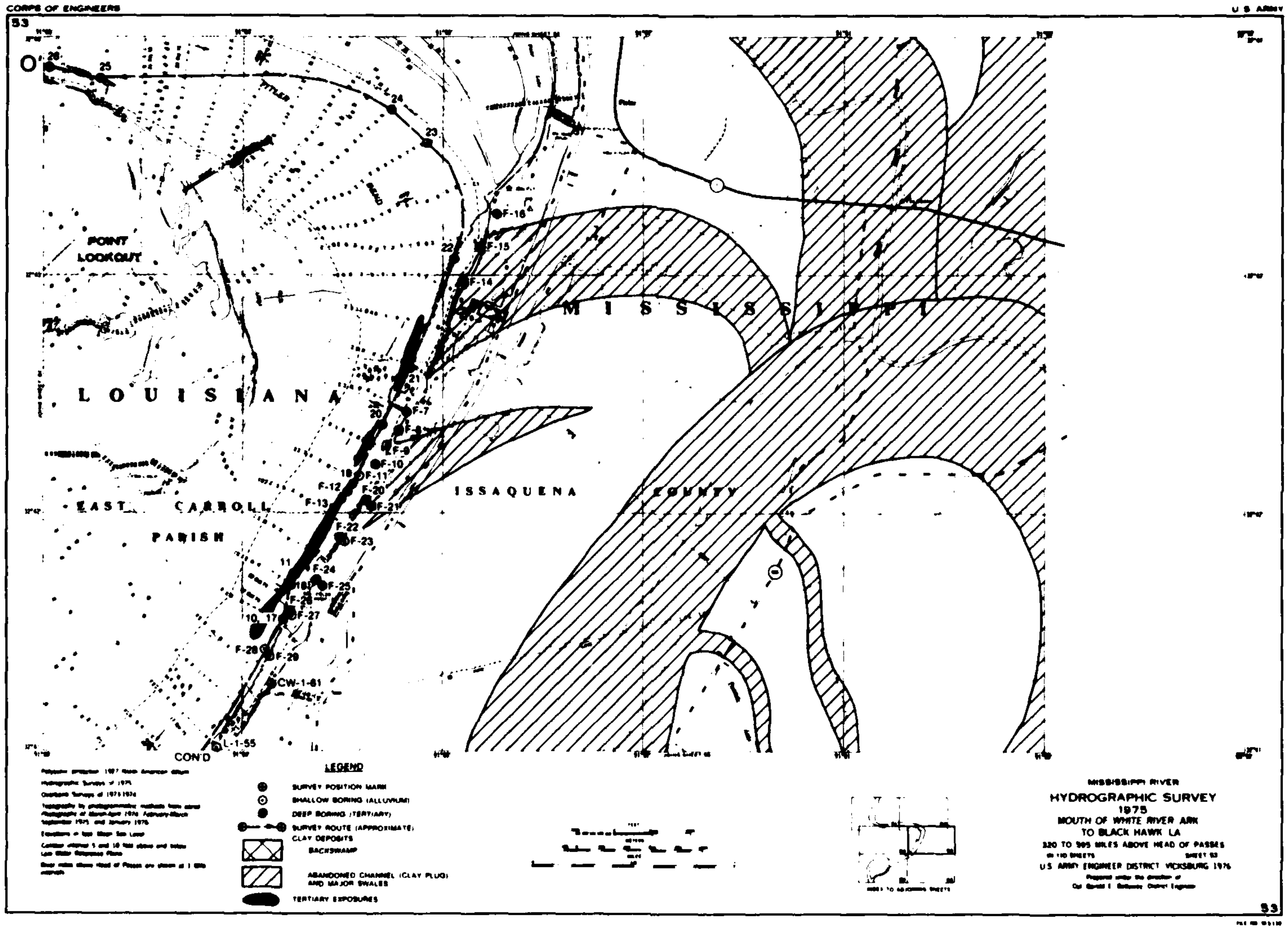
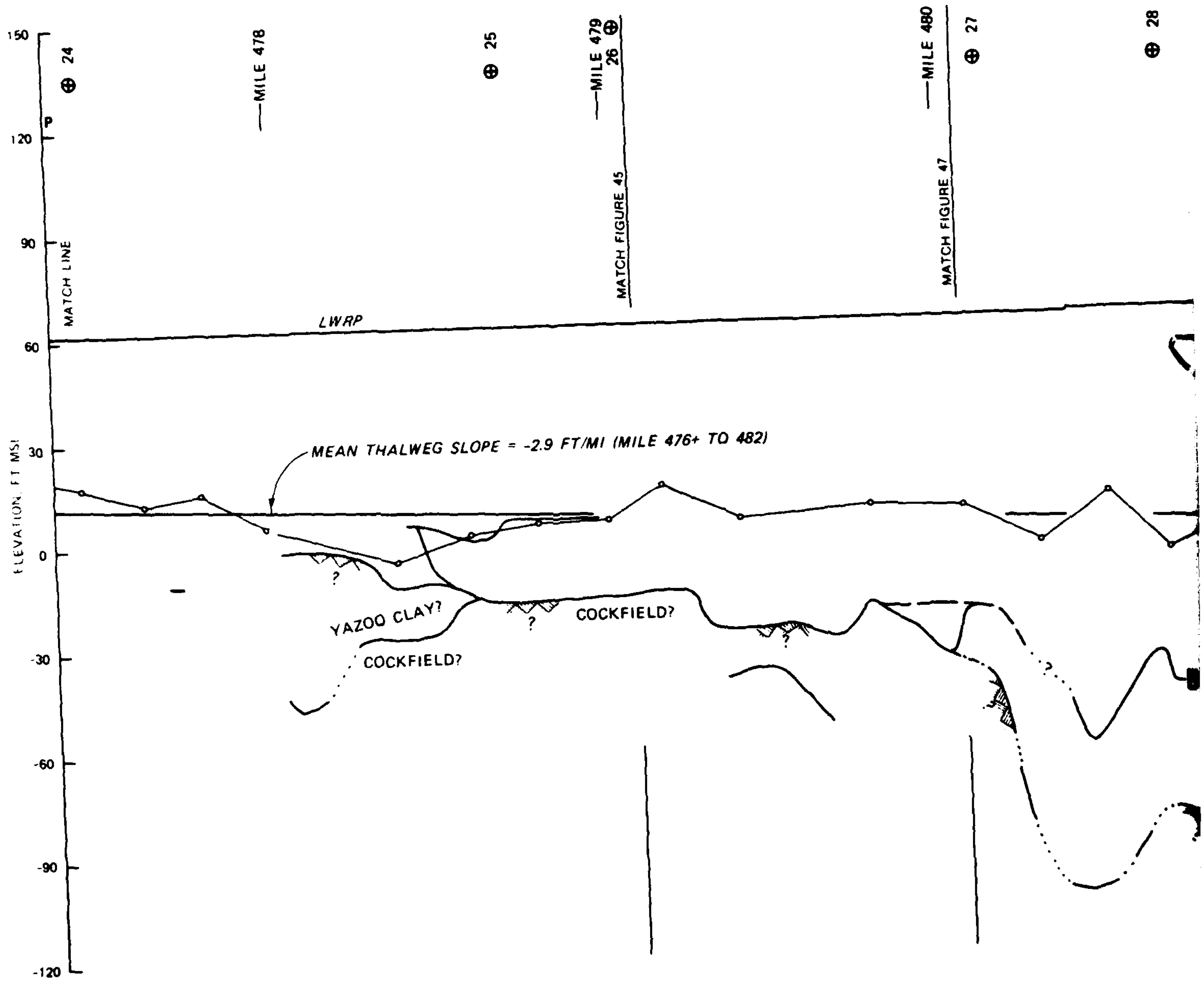


Figure 45. Geologic map, Mississippi River, 474.0 to 479.1 MAHP



150
120
90
60
30
0
-30
-60
-90
-120
ELEVATION, FT MSL
P
24
MILE 478
25
MILE 479
26
MILE 480
27
28
MATCH LINE
MATCH FIGURE 45
MATCH FIGURE 47
LWRP
MEAN THALWEG SLOPE = -2.9 FT/MI (MILE 476+ TO 482)
YAZOO CLAY?
COCKFIELD?
COCKFIELD?

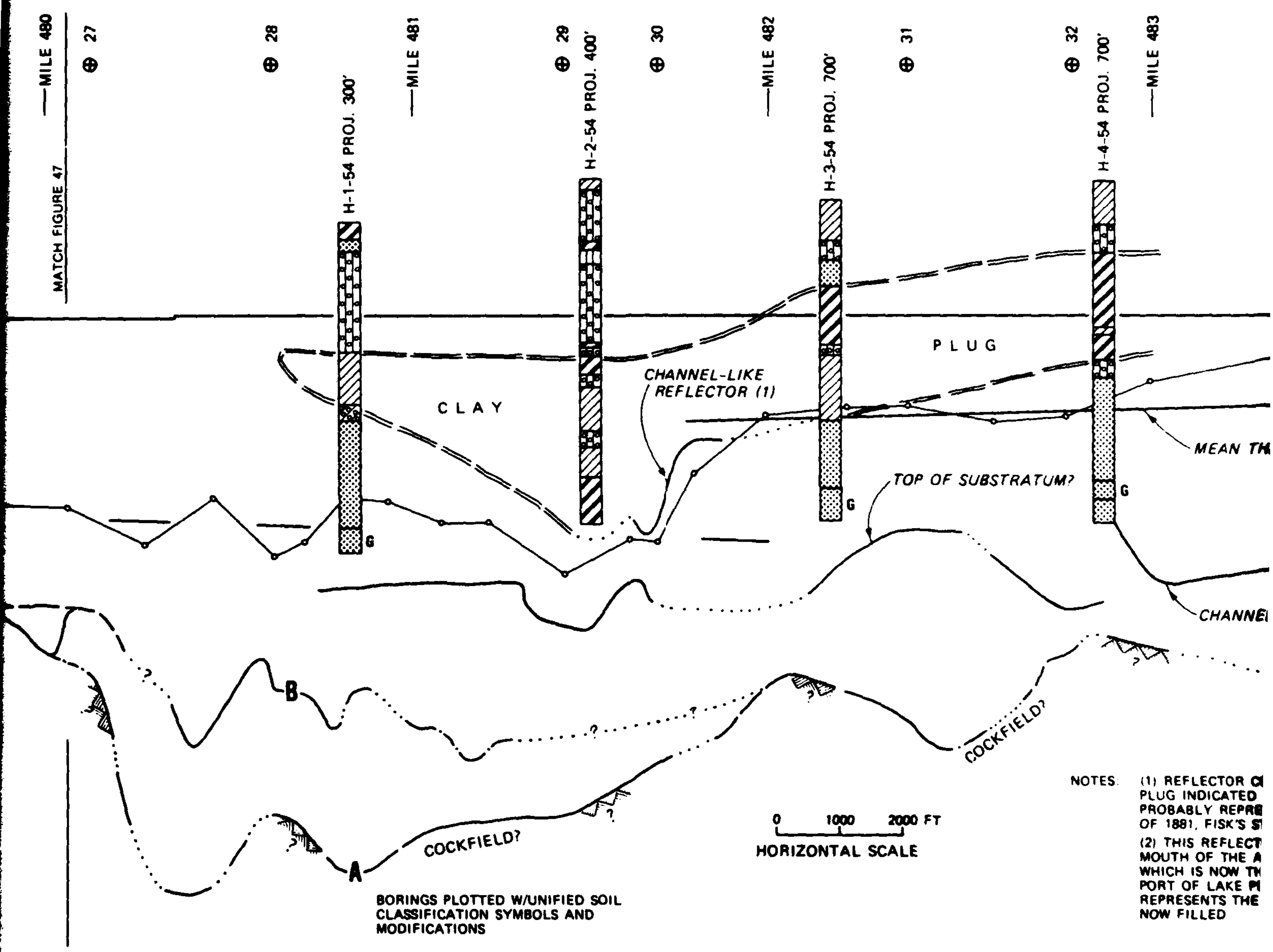
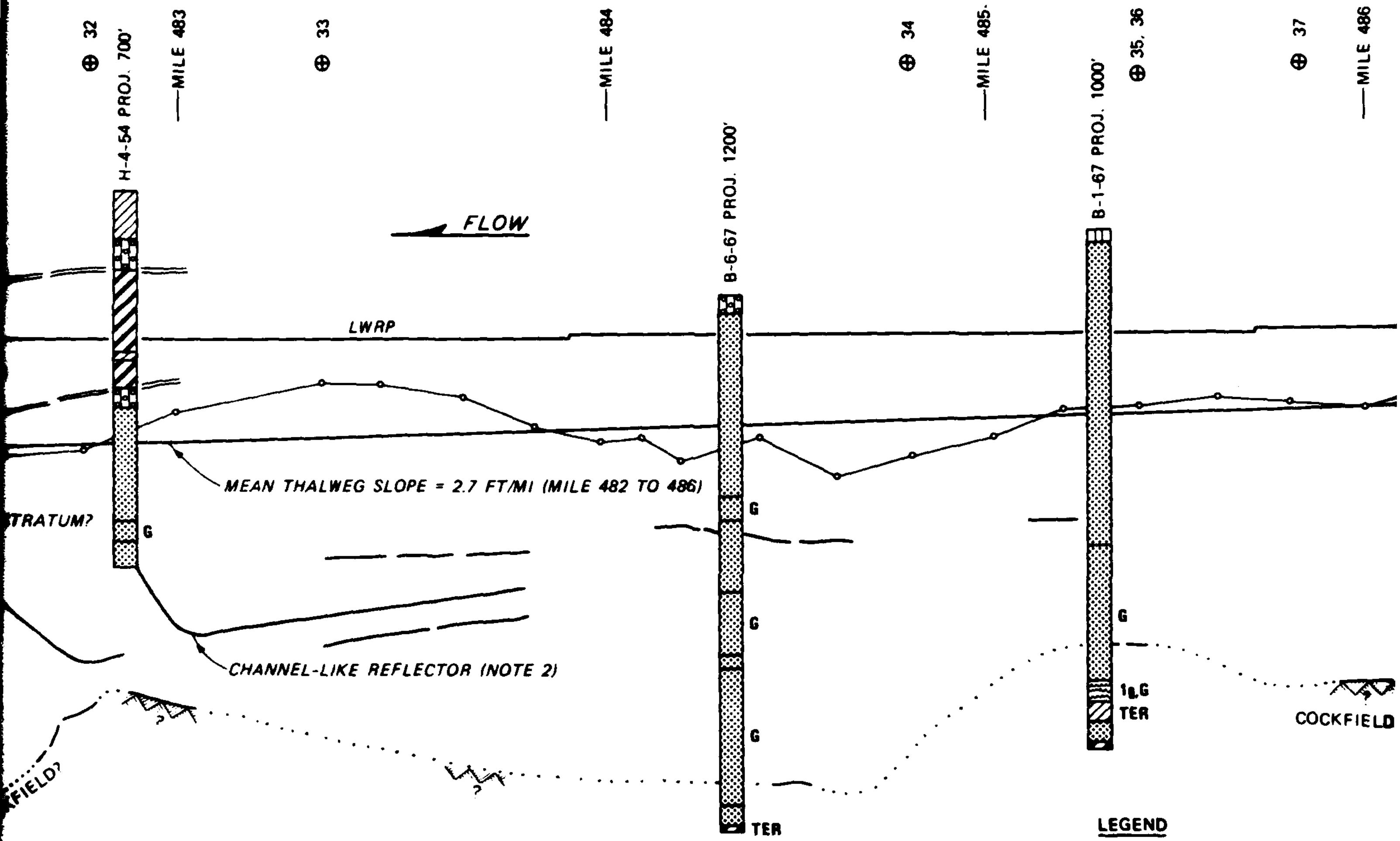


Figure 46. Profile PP', Mississippi River, 477.2 to 486.3 MAHP



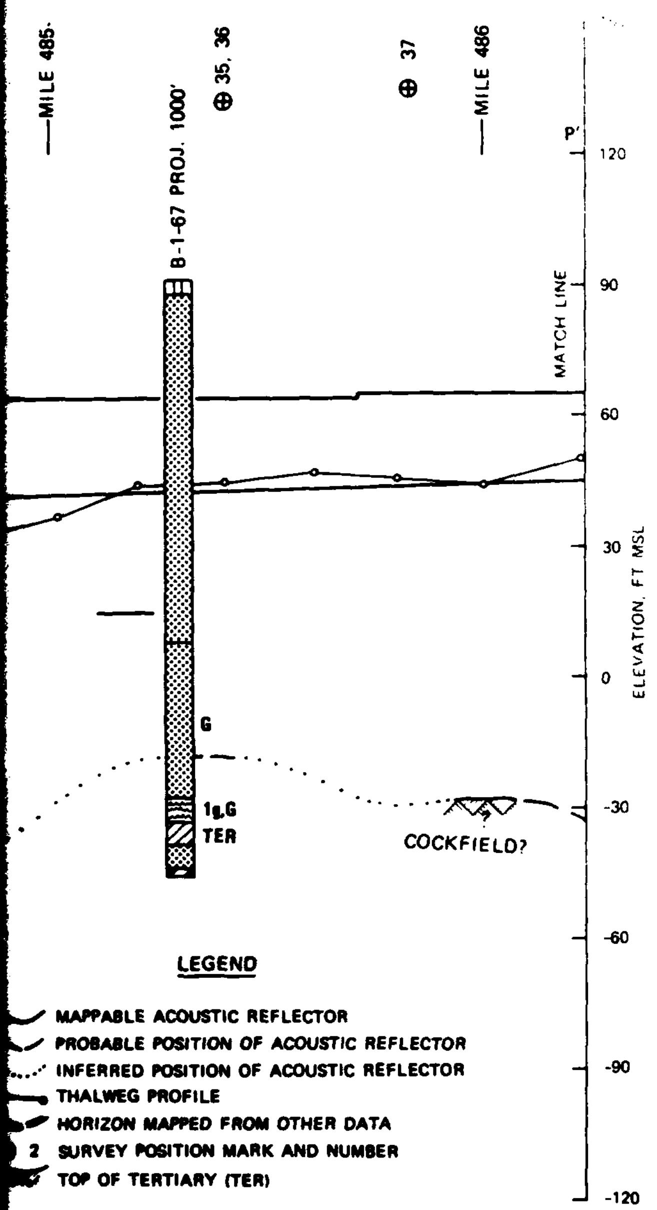
NOTES: (1) REFLECTOR COINCIDES WITH POSITION OF CLAY PLUG INDICATED BY BORINGS. THIS CLAY PLUG PROBABLY REPRESENTS THE HISTORICAL CHANNEL OF 1881, FISK'S STAGE 19 (FISK 1944, PLATE 22)

(2) THIS REFLECTOR APPEARS AT THE PRESENT MOUTH OF THE ABANDONED HAGAMAN CHANNEL, WHICH IS NOW THE ENTRANCE CHANNEL TO THE PORT OF LAKE PROVIDENCE. PRESUMABLY, IT REPRESENTS THE BASE OF THE FORMER CHANNEL, NOW FILLED

LEGEND

- MAPPABLE ACOUSTIC REFLECTOR
- PROBABLE POSITION OF ACOUSTIC REFLECTOR
- INFERRED POSITION OF ACOUSTIC REFLECTOR
- THALWEG PROFILE
- HORIZON MAPPED FROM OTHER DATA
- 2 SURVEY POSITION MARK AND NUMBER
- TOP OF TERTIARY (TER)

486.3 MAHP



MILE 485
B-1-67 PROJ. 1000'
⊕ 35, 36
⊕ 37
MILE 486
P'
MATCH LINE
120
90
60
30
0
-30
-60
-90
-120
ELEVATION, FT MSL
G
Ig,G
TER
COCKFIELD?
LEGEND
MAPPABLE ACOUSTIC REFLECTOR
PROBABLE POSITION OF ACOUSTIC REFLECTOR
INFERRED POSITION OF ACOUSTIC REFLECTOR
THALWEG PROFILE
HORIZON MAPPED FROM OTHER DATA
2 SURVEY POSITION MARK AND NUMBER
TOP OF TERTIARY (TER)

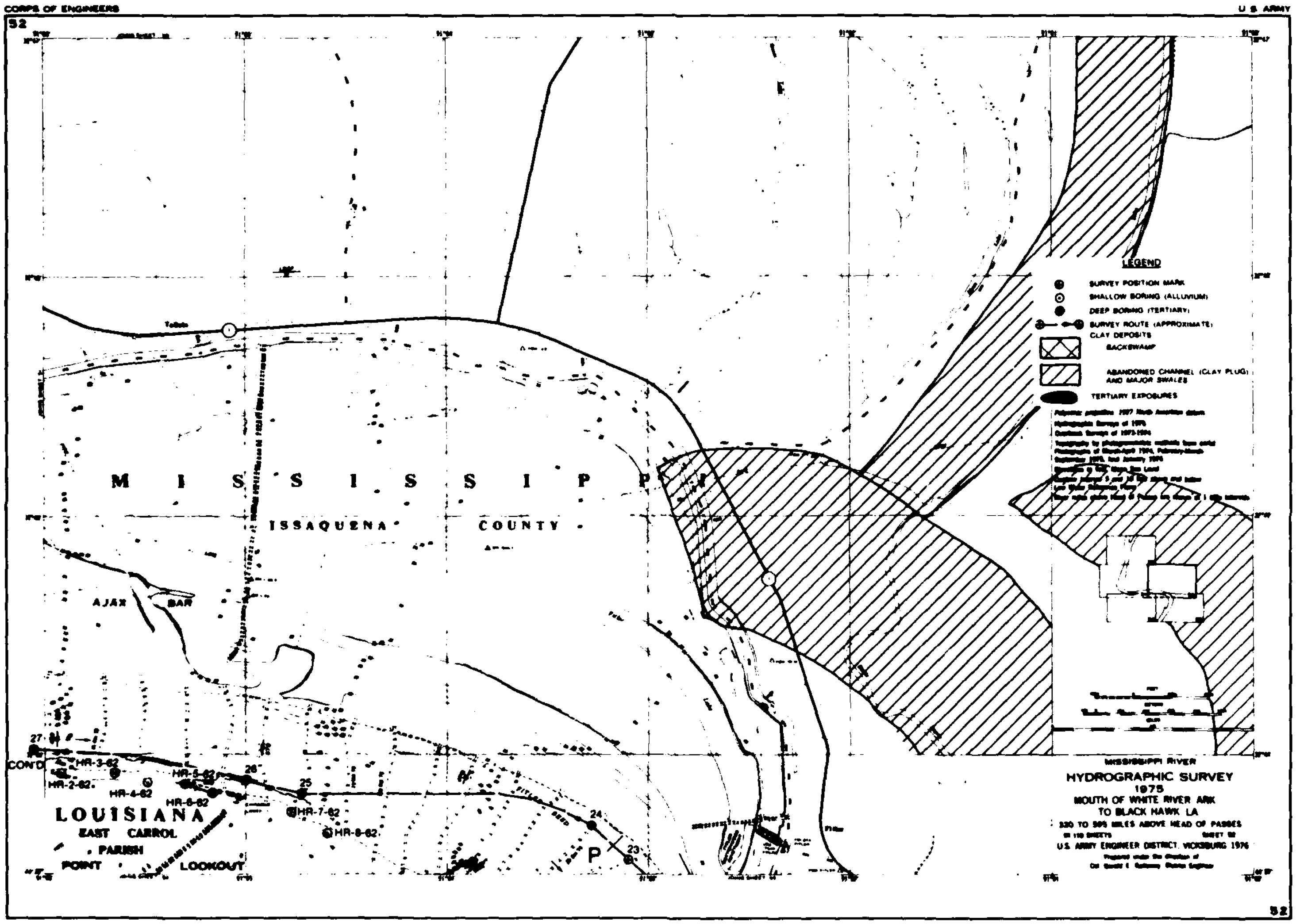


Figure 47. Geologic map, Mississippi River, 477.2 to 480.1 MAHP

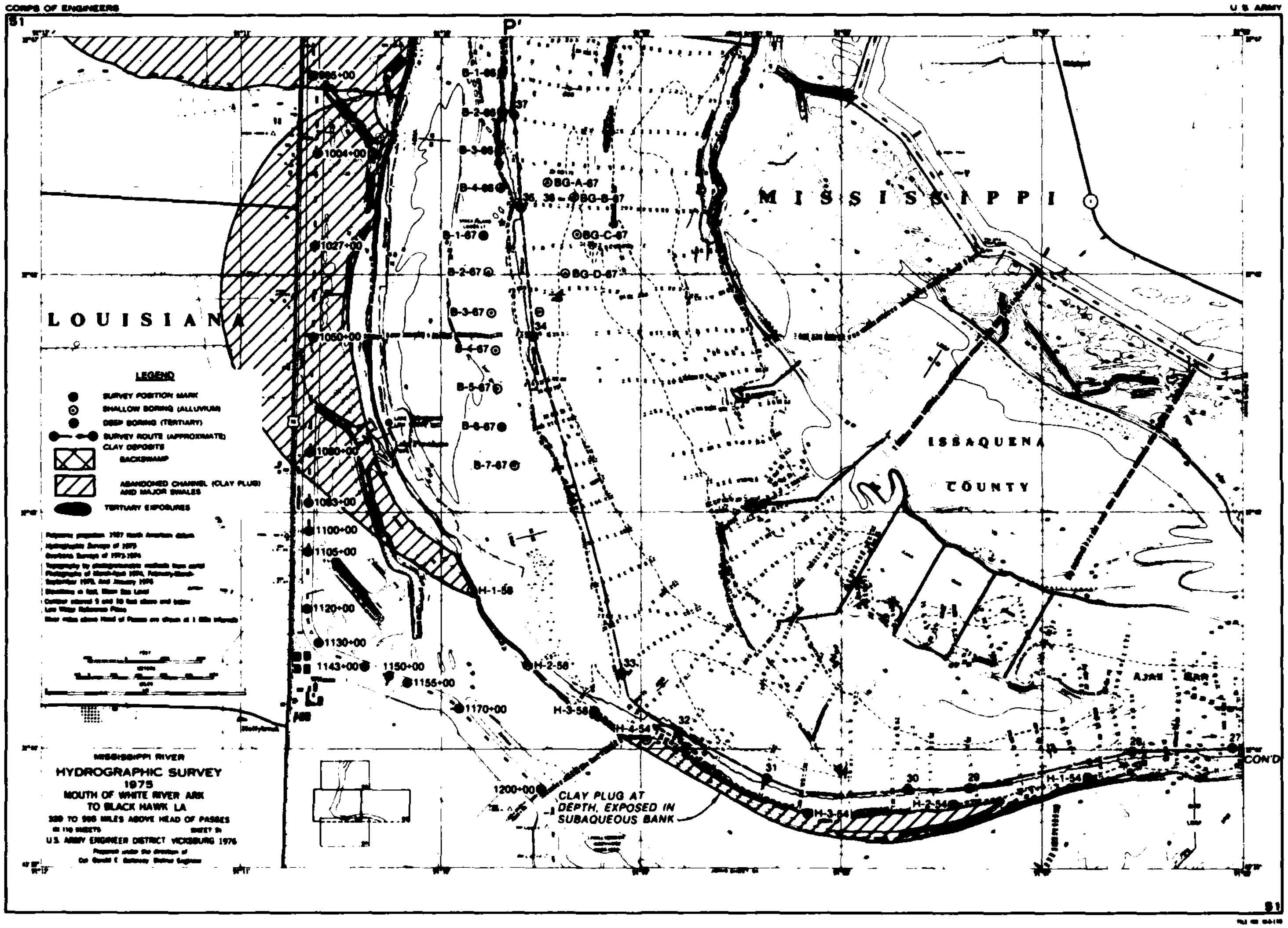


Figure 48. Geologic map, Mississippi River, 480.1 to 486.3 MAHP

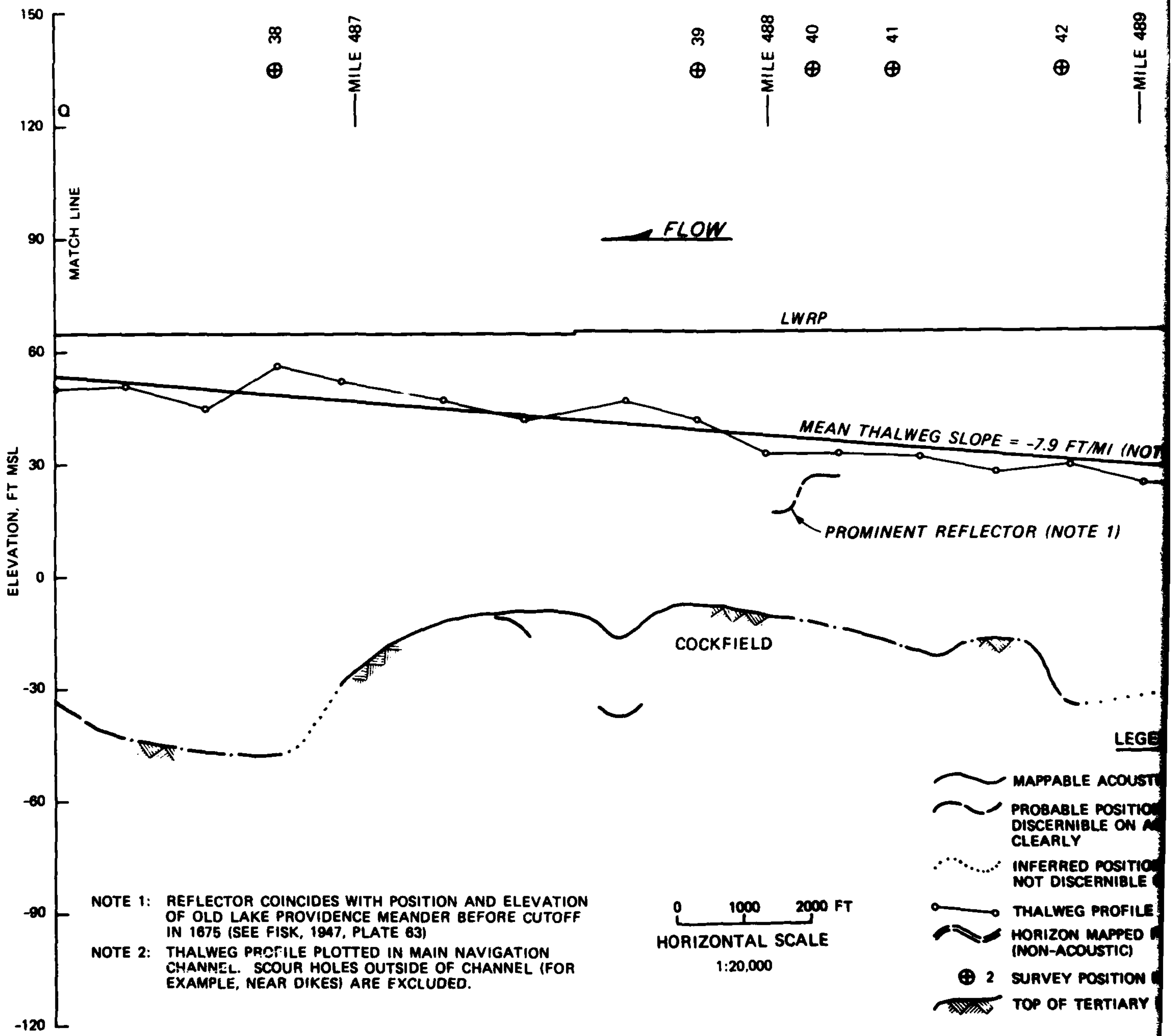
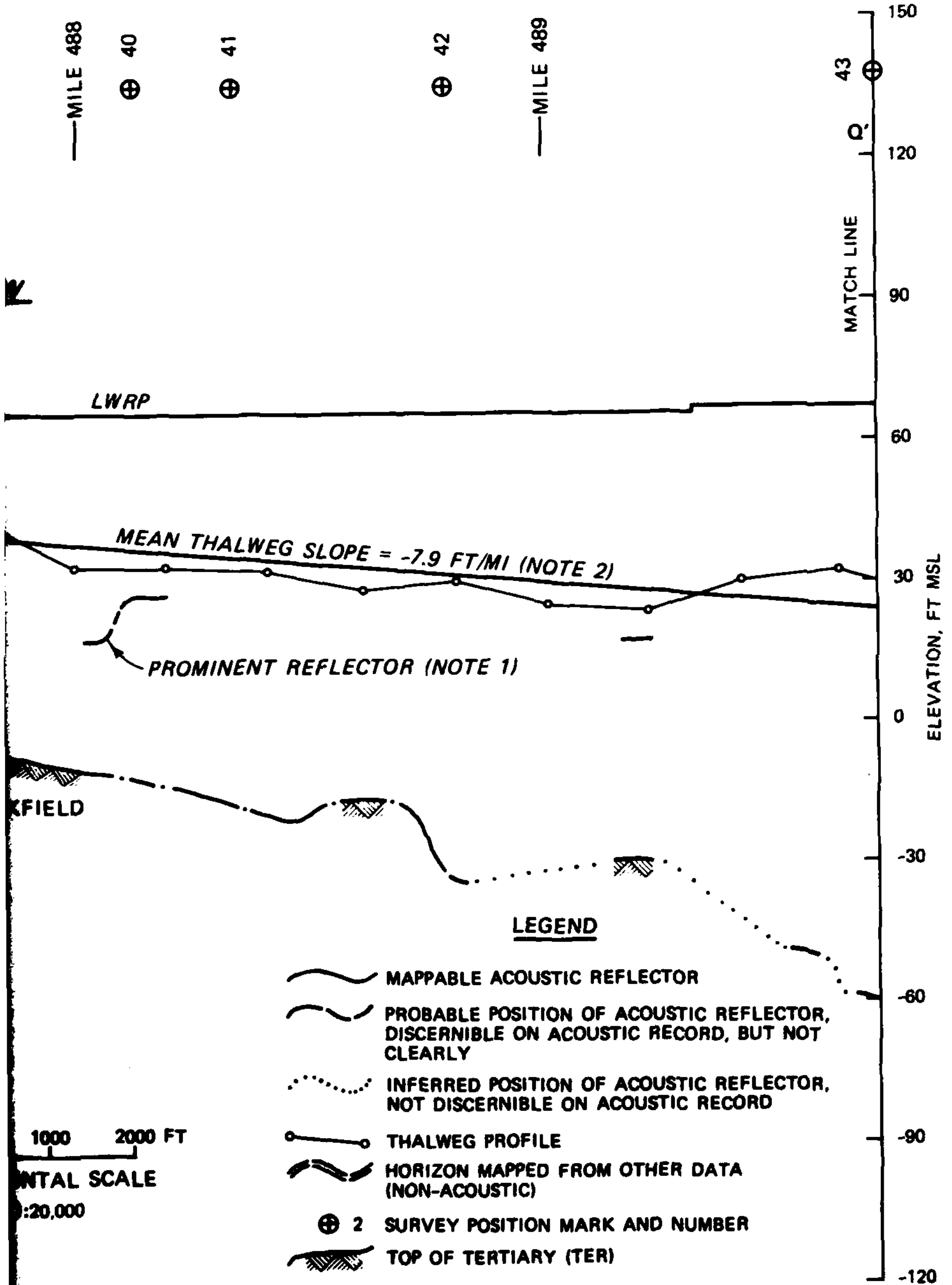


Figure 49. Profile QQ', Mississippi River, 486.3 to 489.8 MAHP



sippi River, 486.3 to 489.8 MAHP

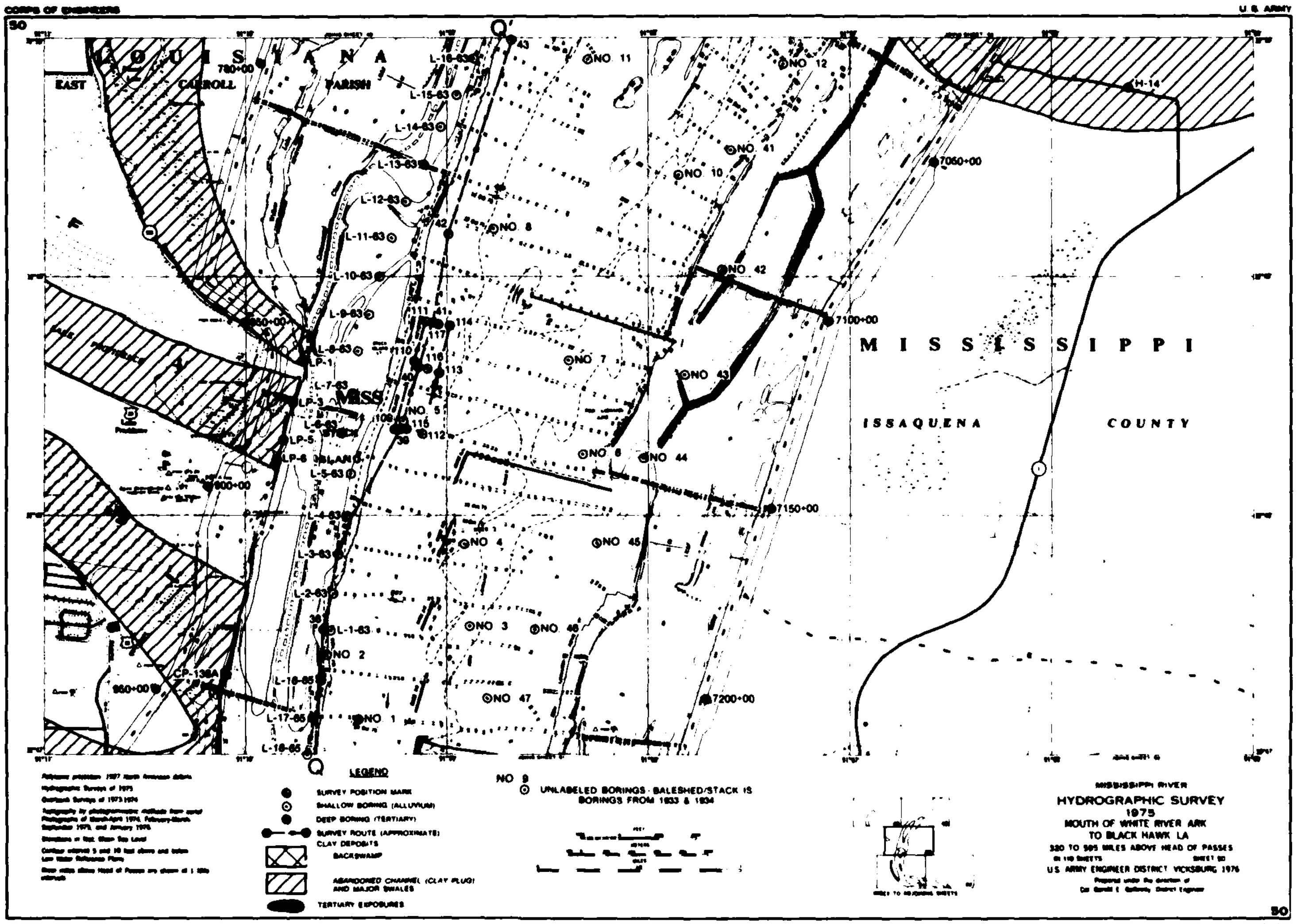


Figure 50. Geologic map, Mississippi River, 486.3 to 489.8 MAHP

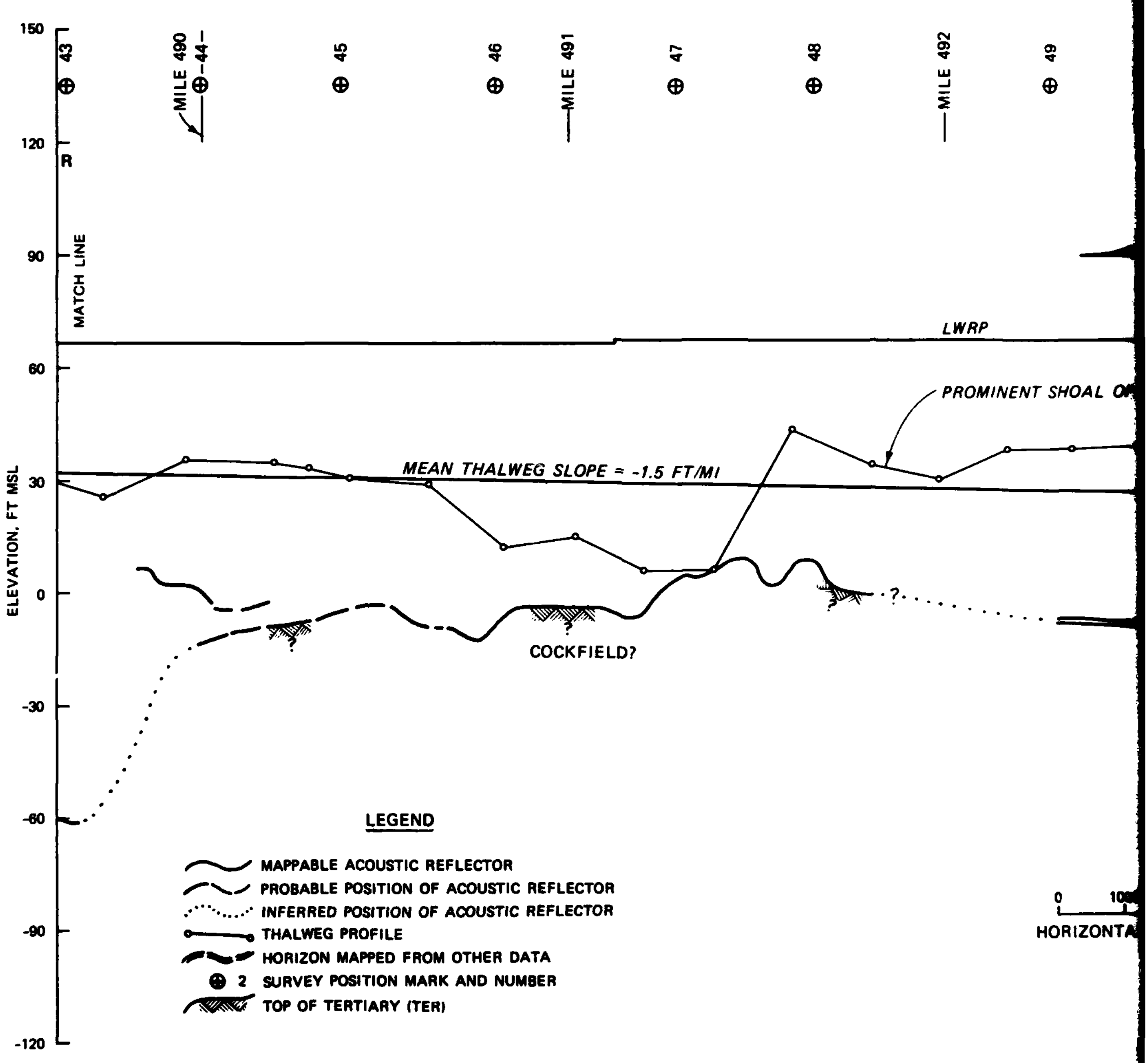
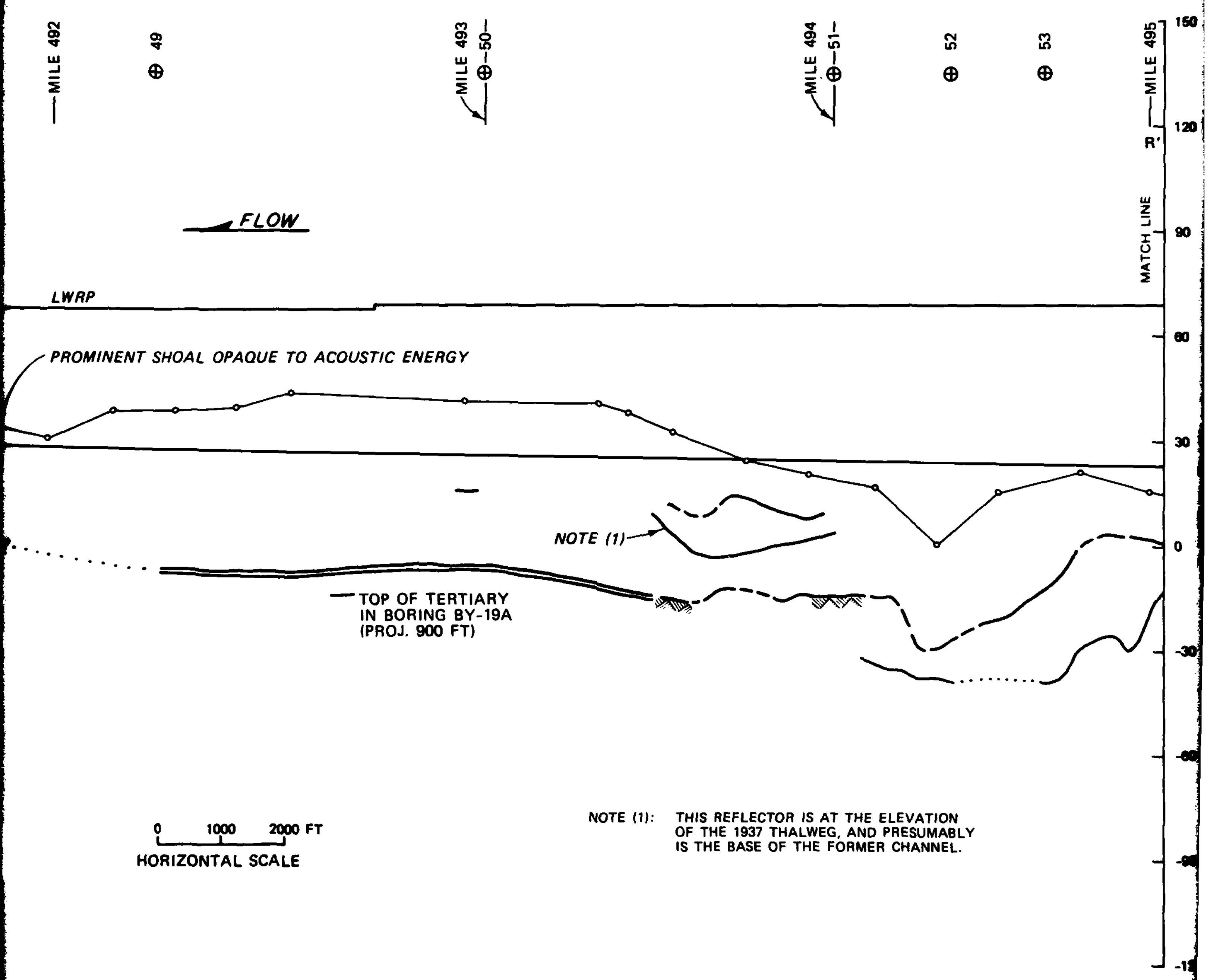
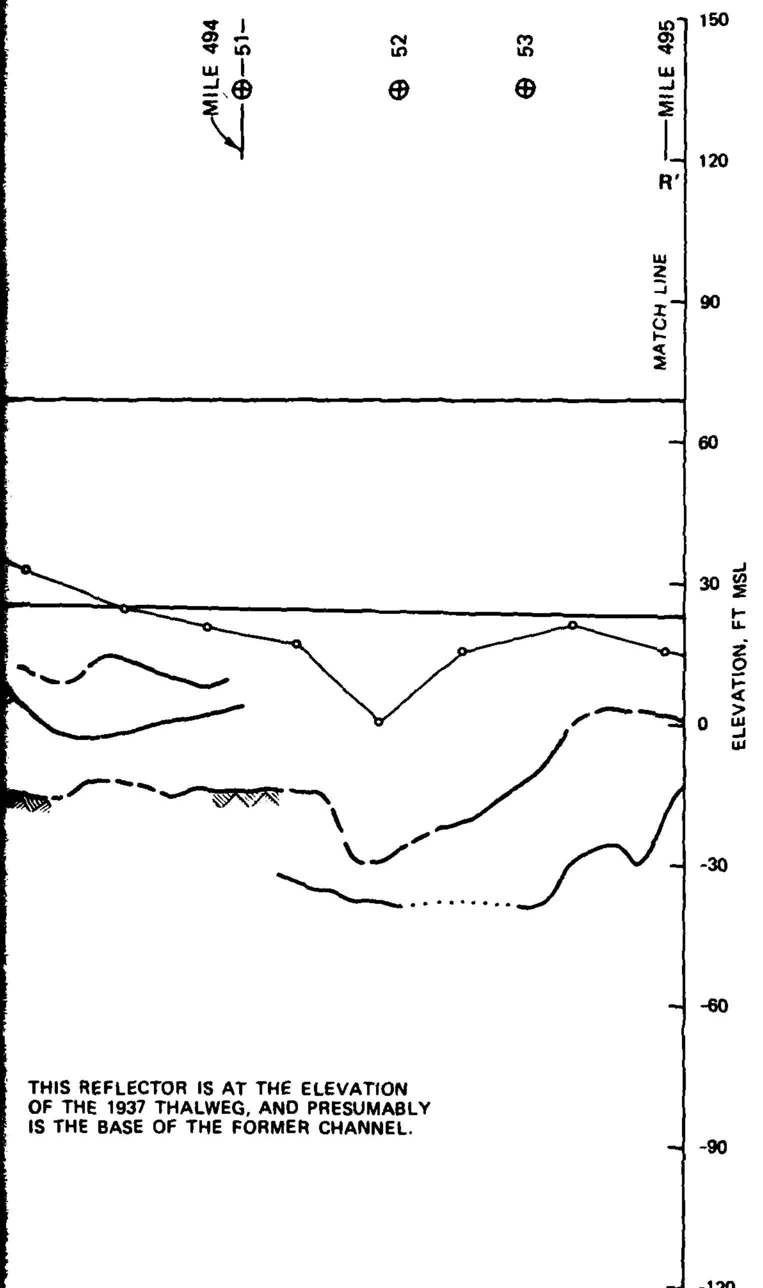


Figure 51. Profile RR', Mississip



ofile RR', Mississippi River, 489.8 to 495.0 MAHP


MILE 494
51
52
53
MILE 495
R'
MATCH LINE
150
120
90
60
30
0
-30
-60
-90
-120
ELEVATION, FT MSL
THIS REFLECTOR IS AT THE ELEVATION
OF THE 1937 THALWEG, AND PRESUMABLY
IS THE BASE OF THE FORMER CHANNEL.

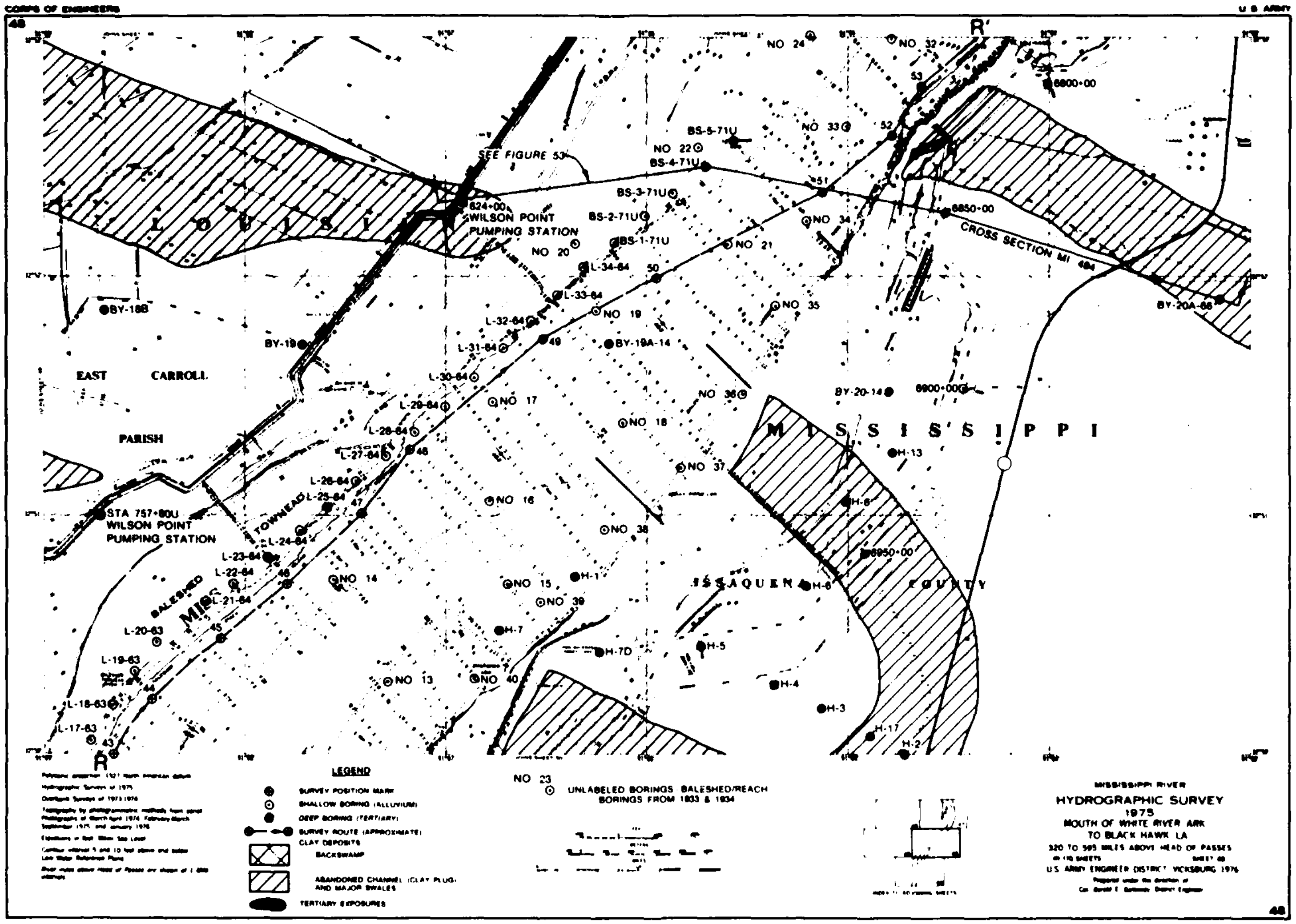


Figure 52. Geologic map, Mississippi River, 489.8 to 495.0 MAHP

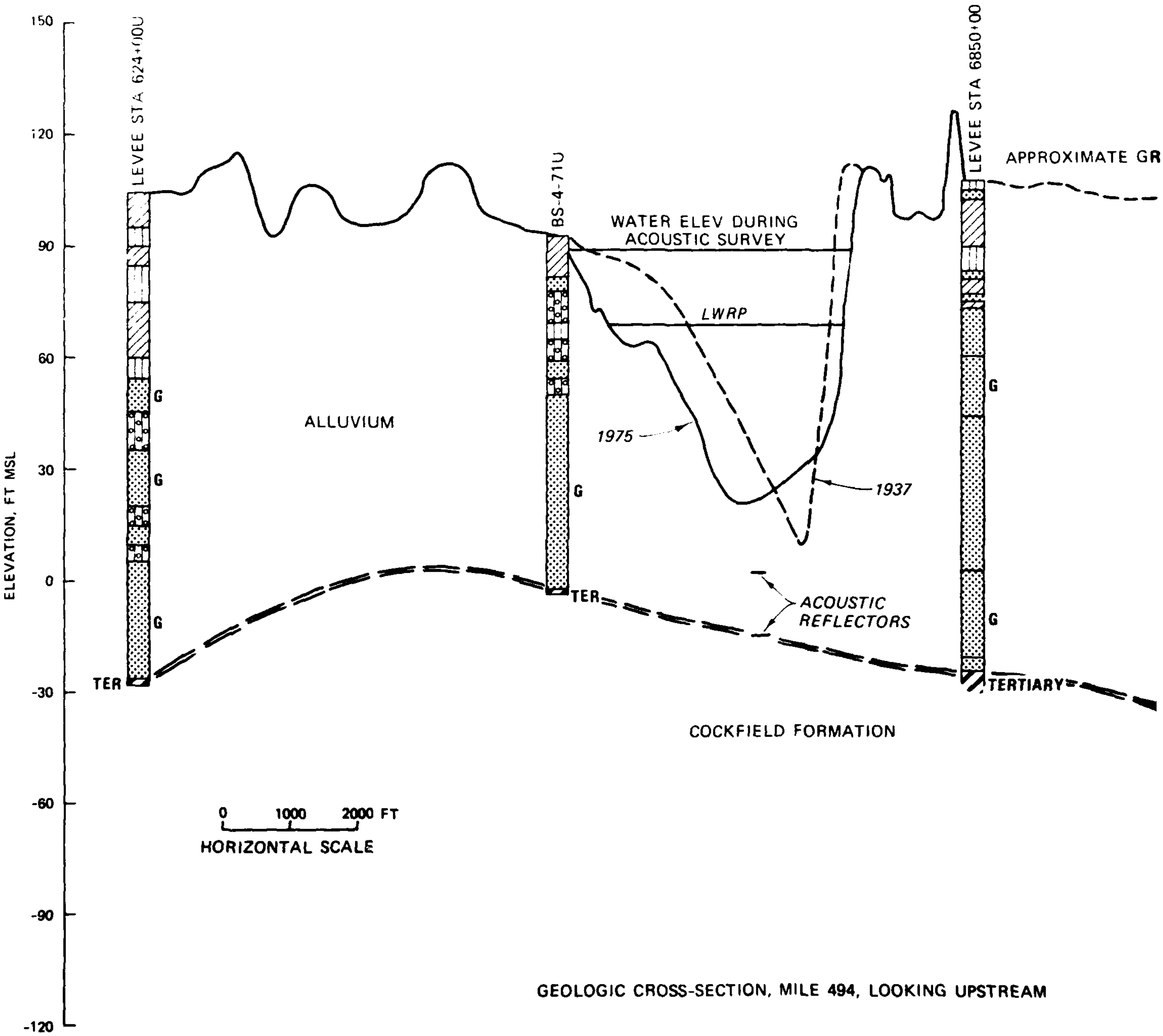
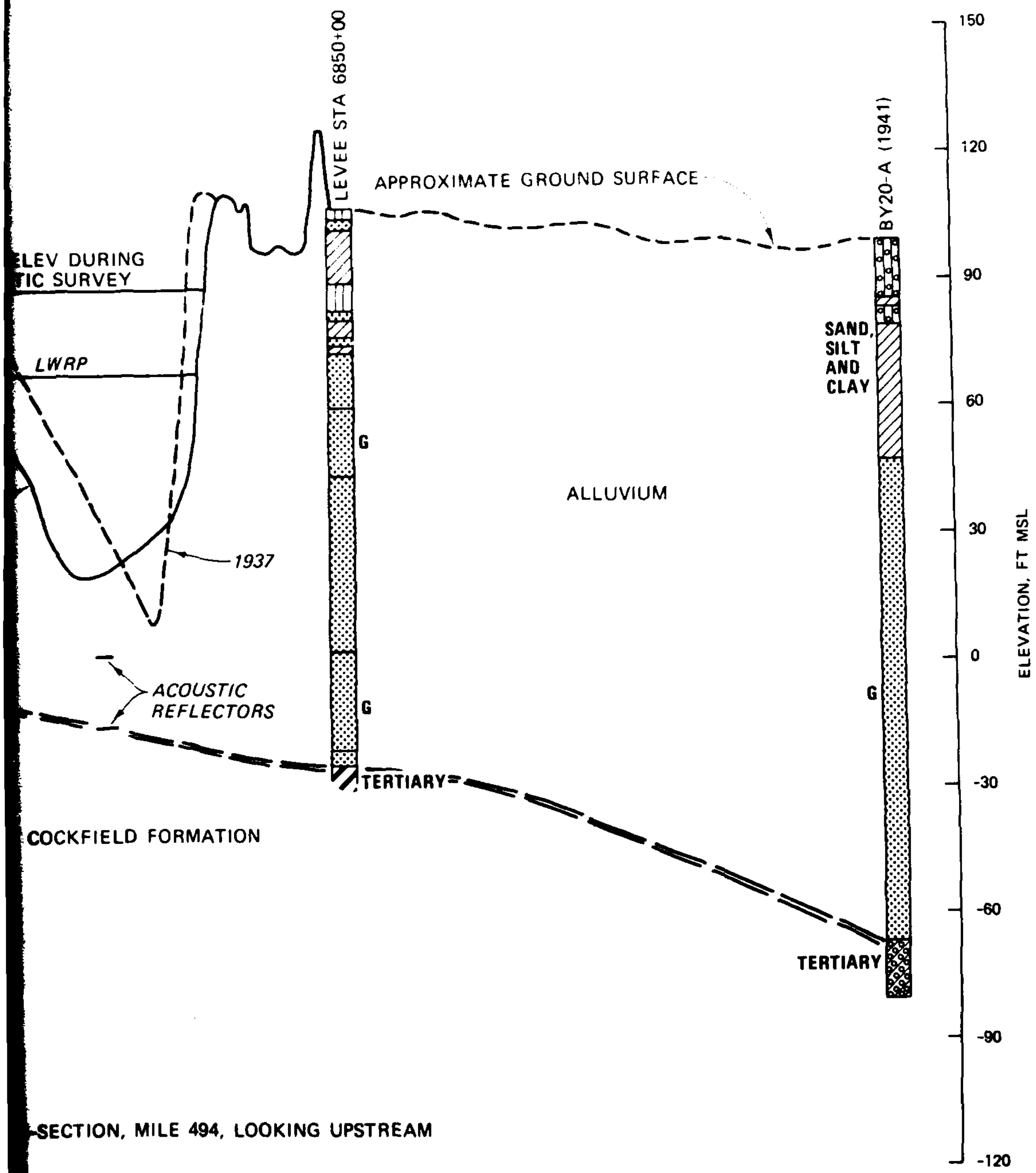


Figure 53. Geologic cross section near Lake Providence, Louisiana, 4



-SECTION, MILE 494, LOOKING UPSTREAM

ction near Lake Providence, Louisiana, 494 MAHP

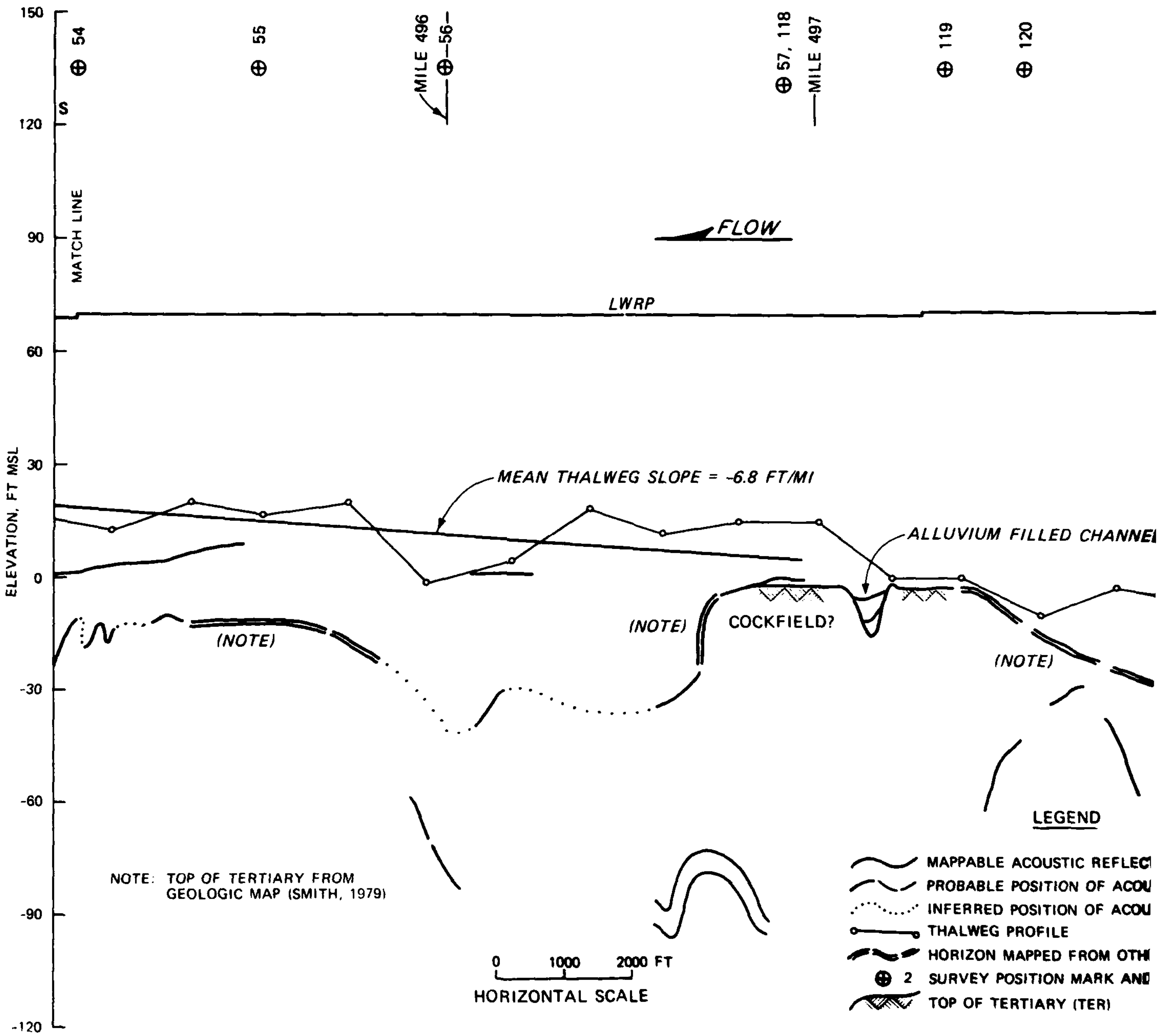
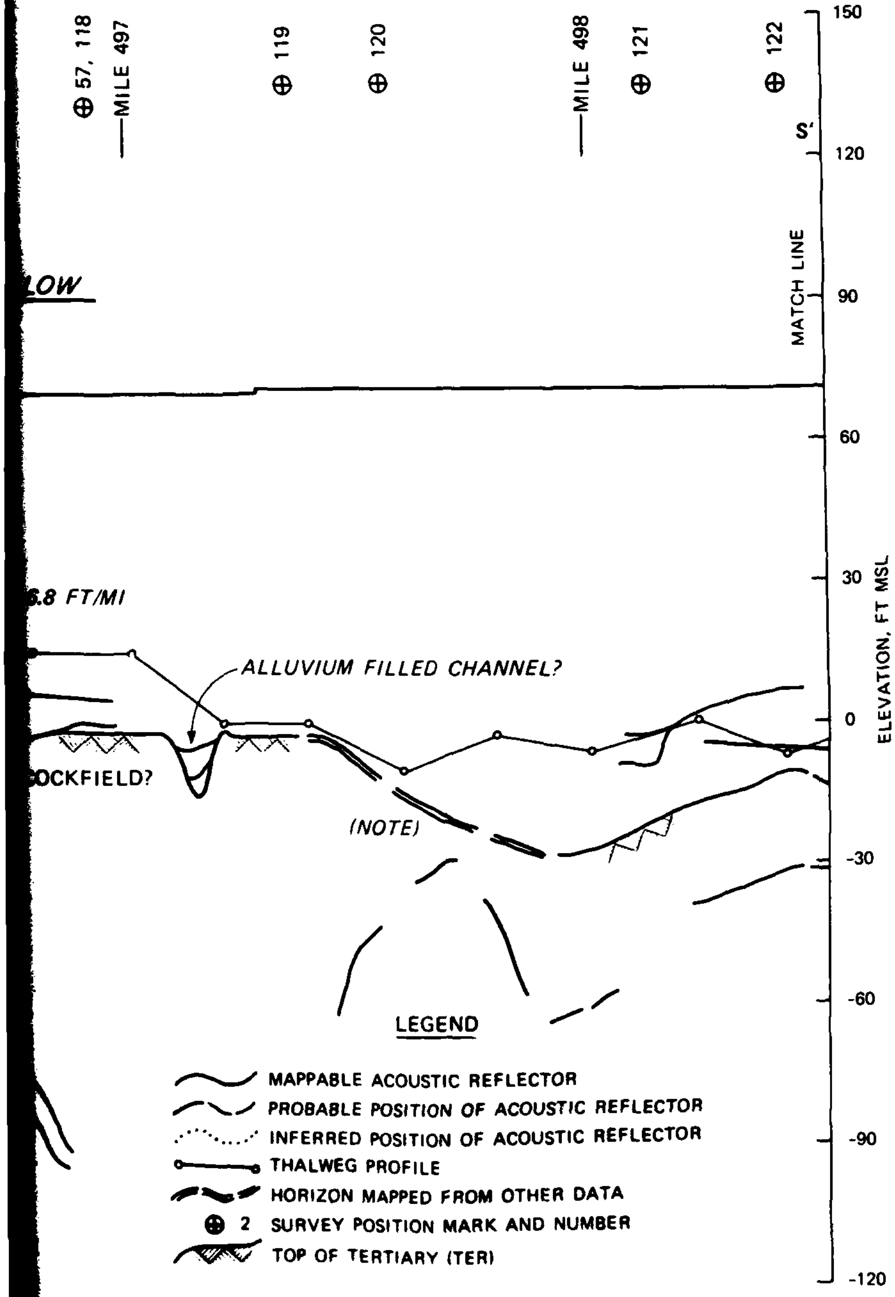


Figure 54. Profile SS', Mississippi River, 495.0 to 498.6 MAHP



pi River, 495.0 to 498.6 MAHP

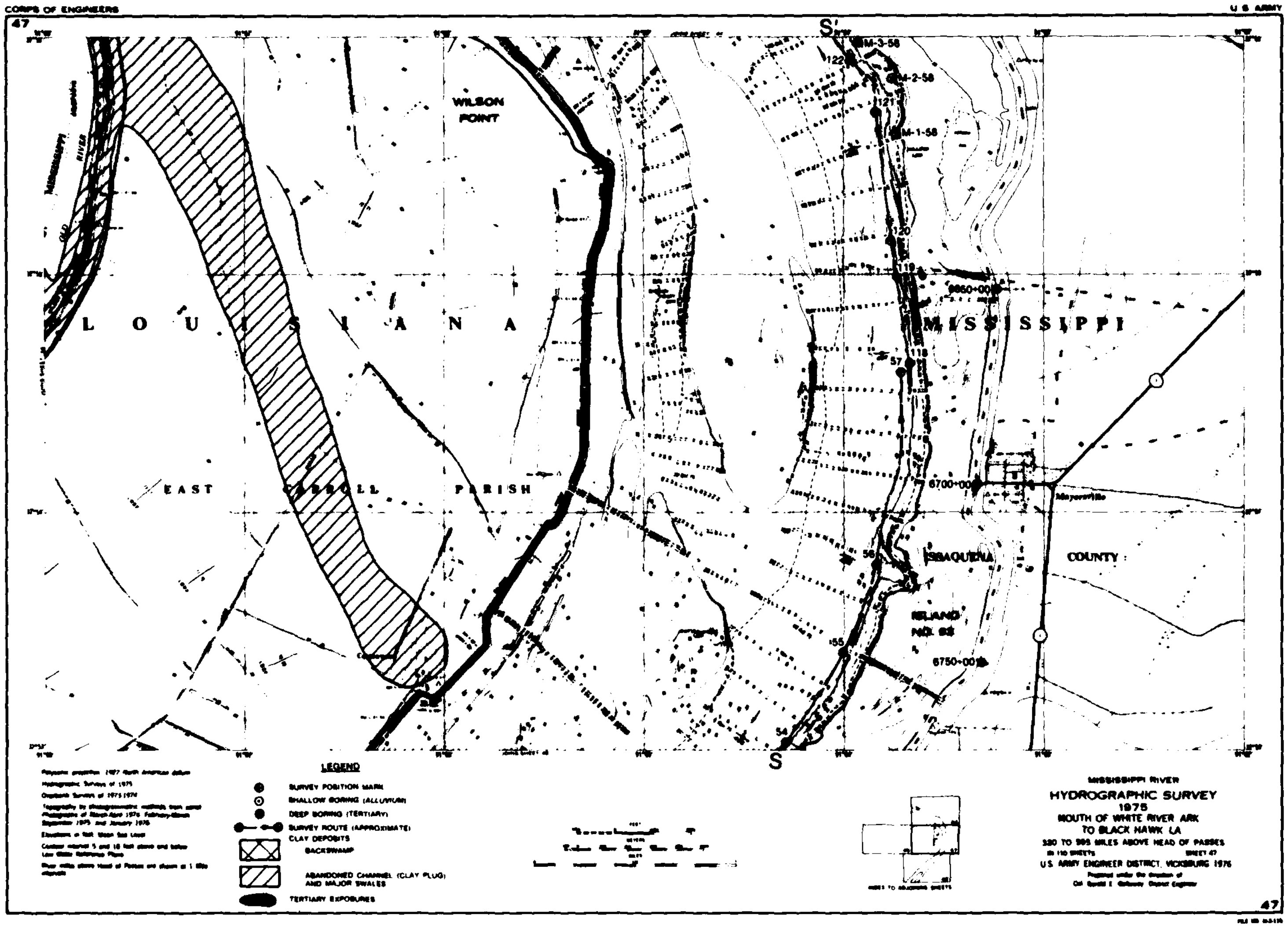


Figure 55. *Geologic map*, Mississippi River, 495.0 to 498.6 MAHP

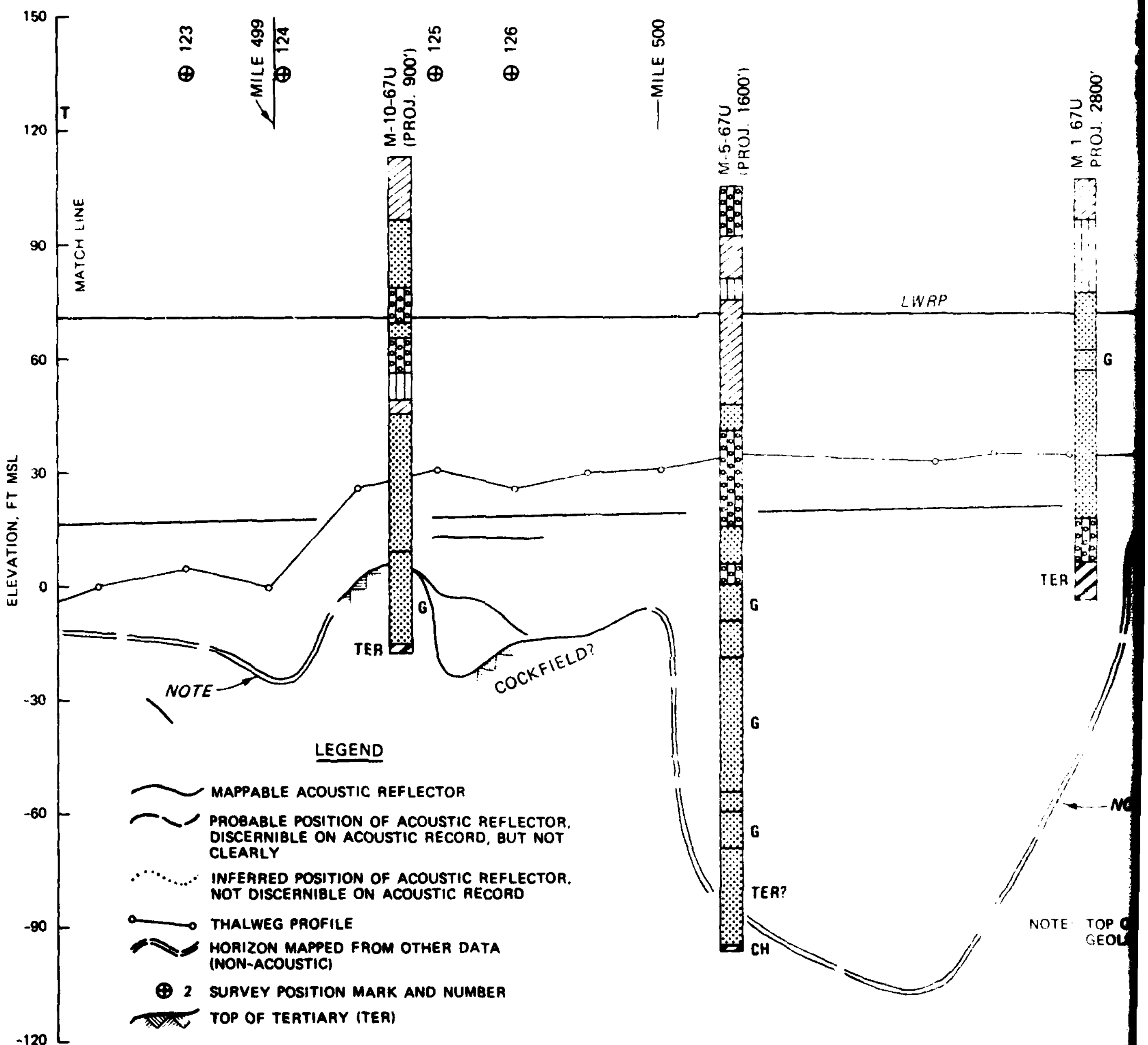
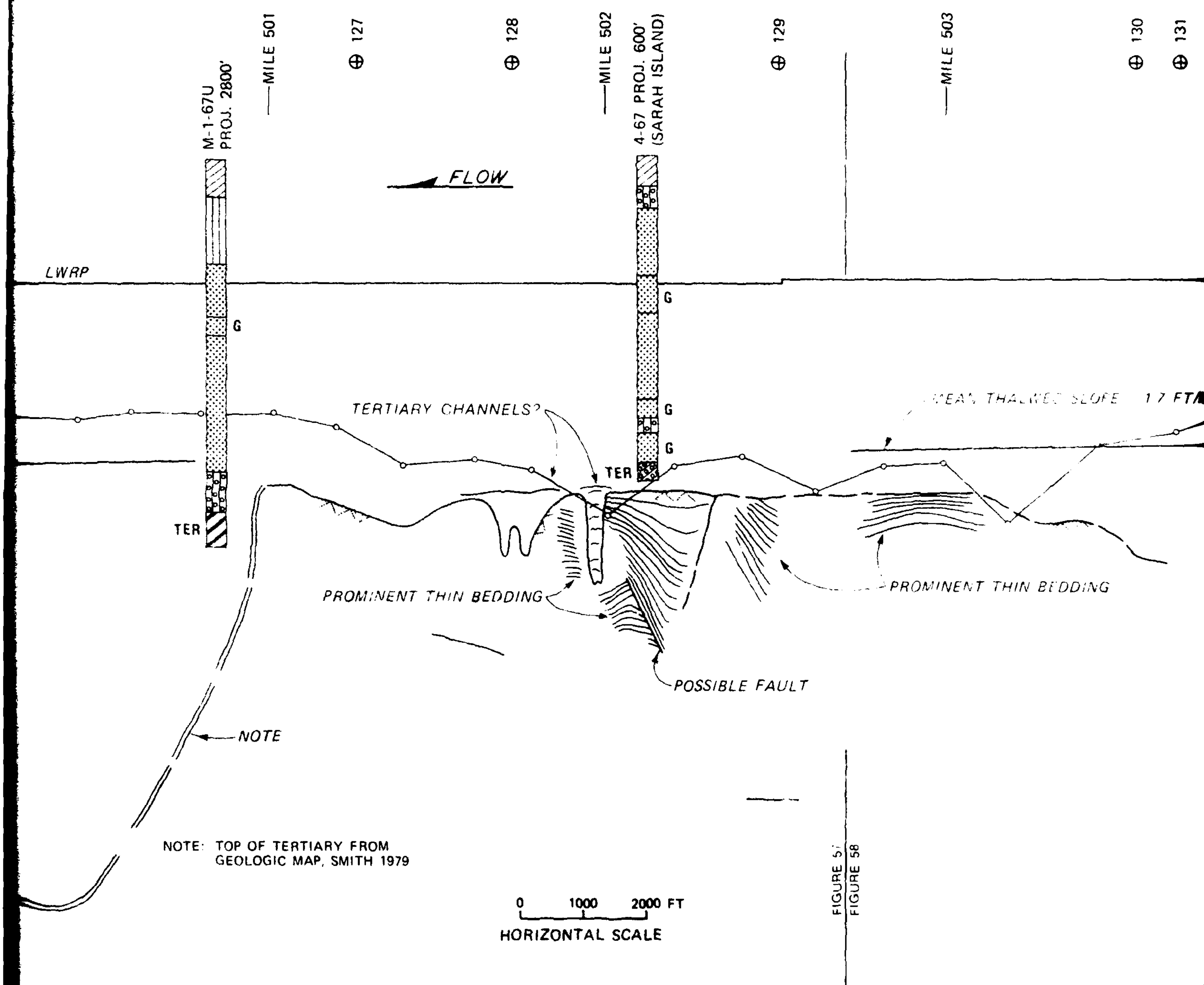
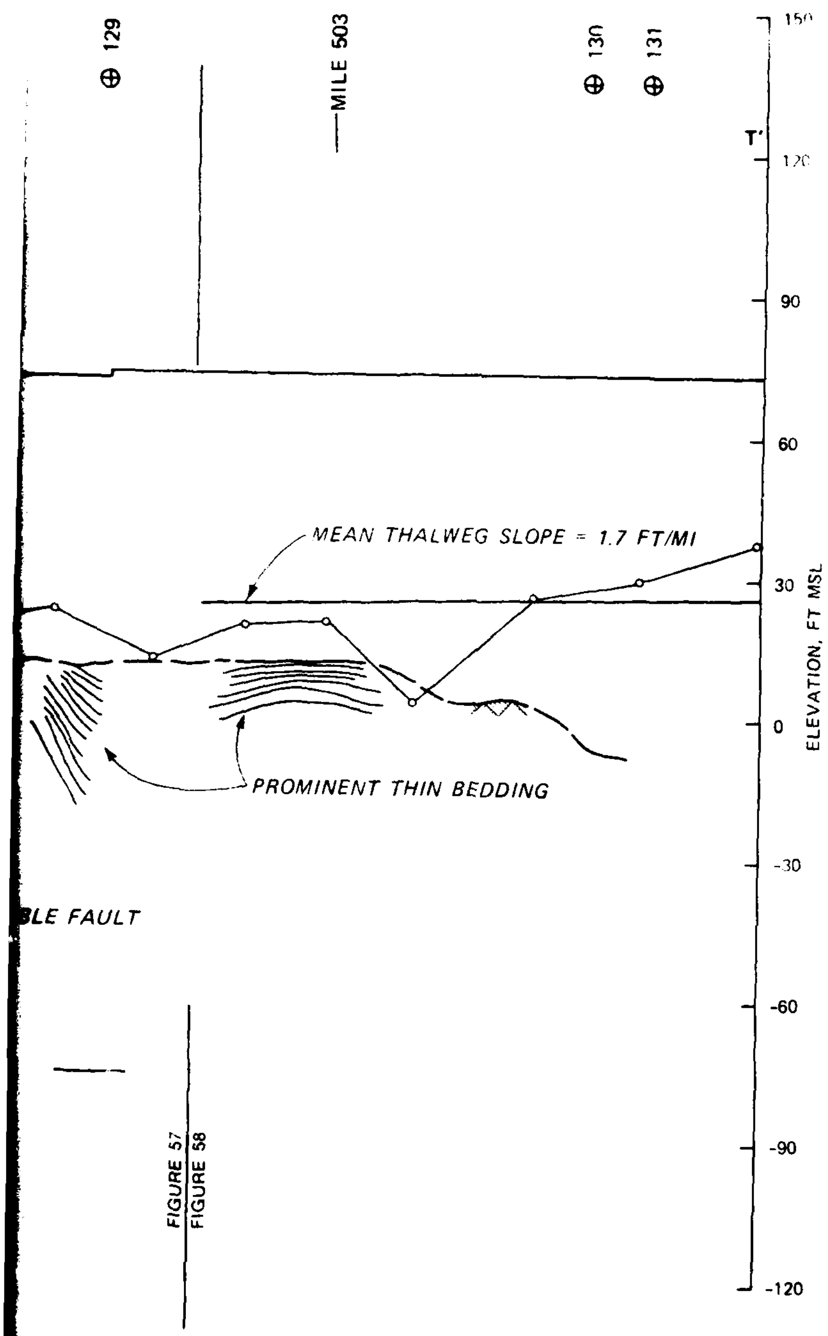


Figure 56. Profile TT', Miss



. Profile TT', Mississippi River, 498.6 to 503.8 MAHP



⊕ 129
MILE 503
⊕ 130
⊕ 131
T'
90
60
30
0
-30
-60
-90
-120
ELEVATION, FT MSL
MEAN THALWEG SLOPE = 1.7 FT/MI
PROMINENT THIN BEDDING
BLE FAULT
FIGURE 57
FIGURE 58

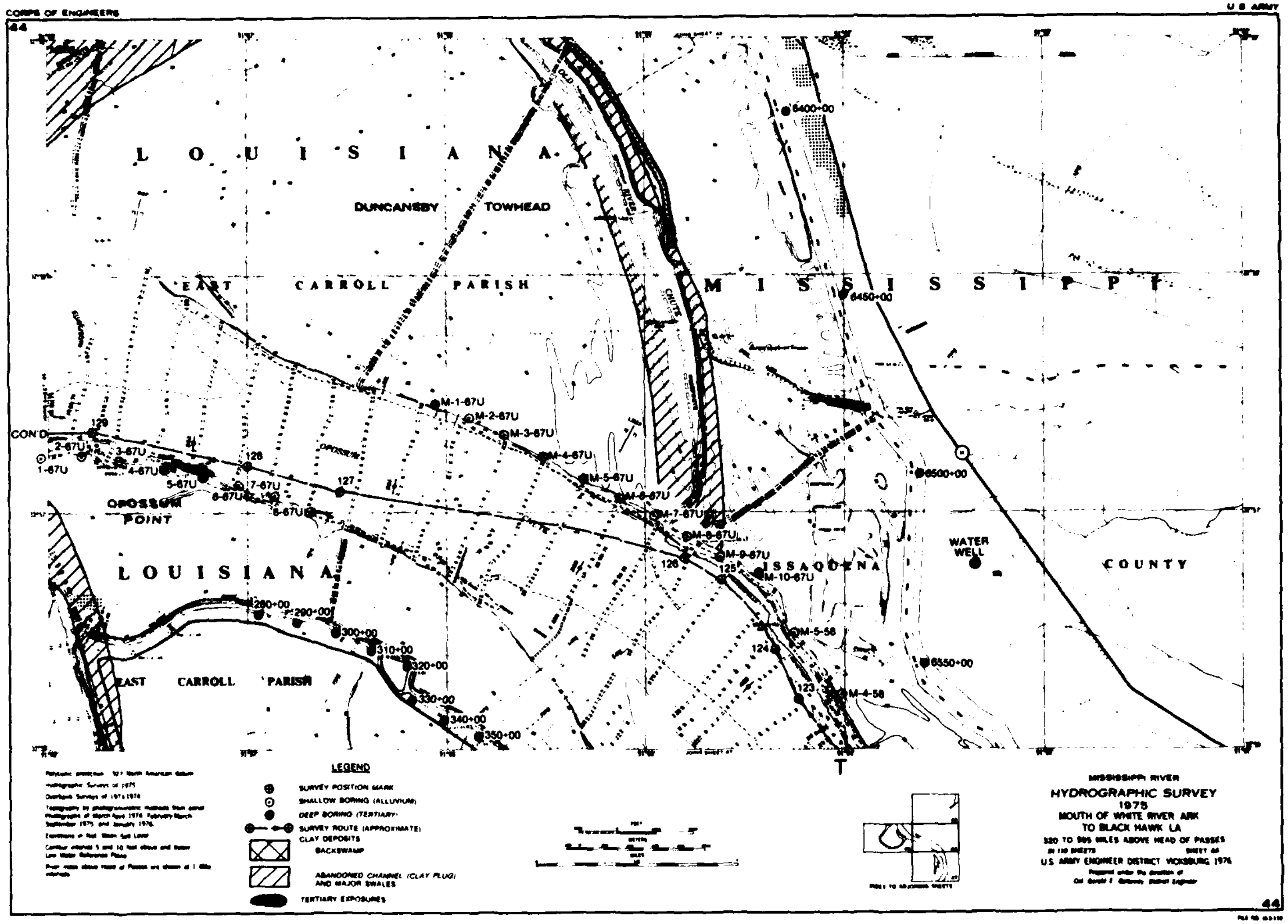


Figure 57. Geologic map, Mississippi River, 498.6 to 502.7 MAHP

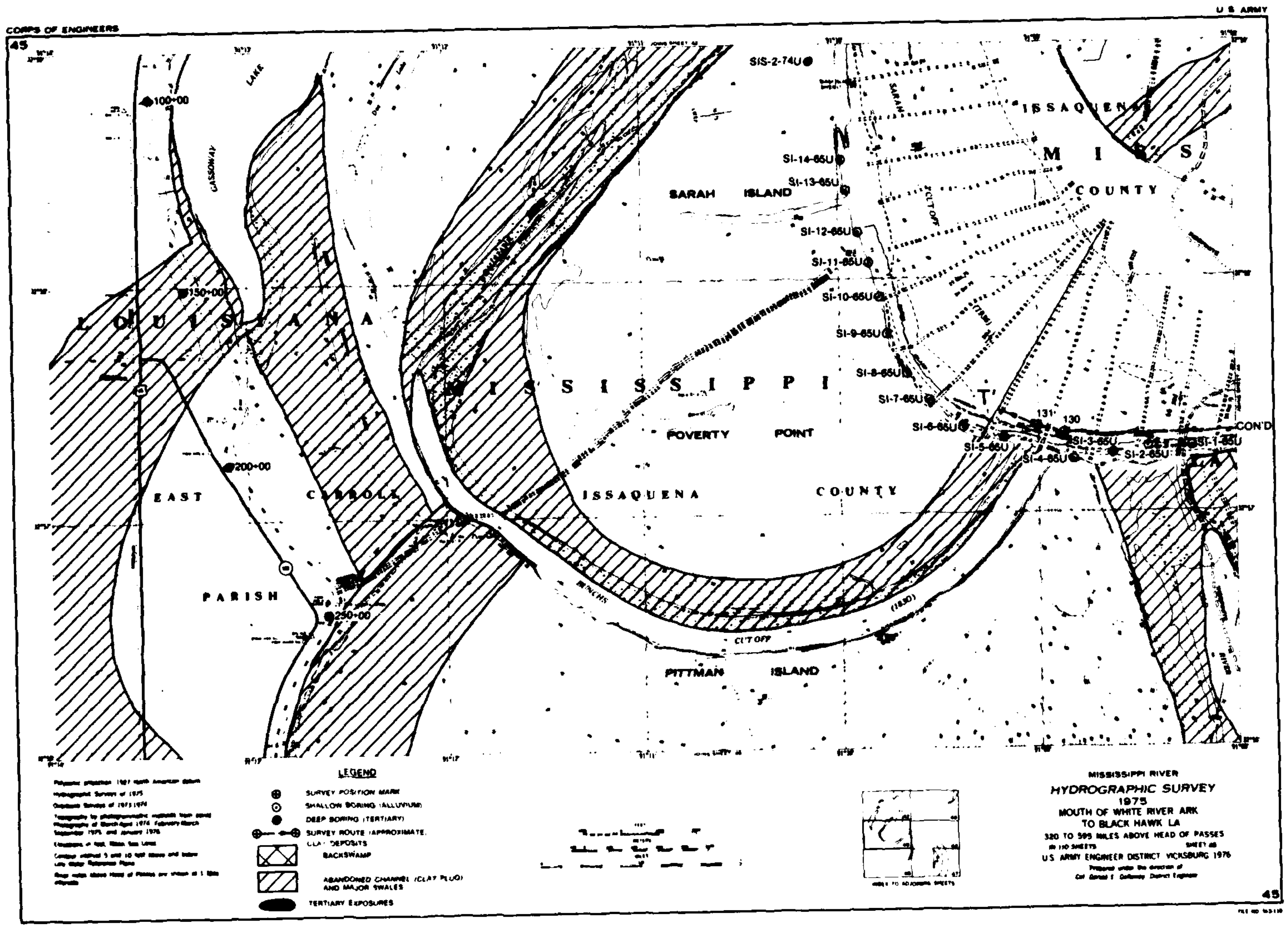


Figure 58. Geologic map, Mississippi River, 502.7 to 505.5 MAHP

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